

Detection and Characterization of the Cosmological Neutrino Background by EPR Spectroscopy on Molecular Hydrino with Implications for Telecommunications

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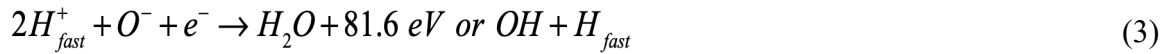
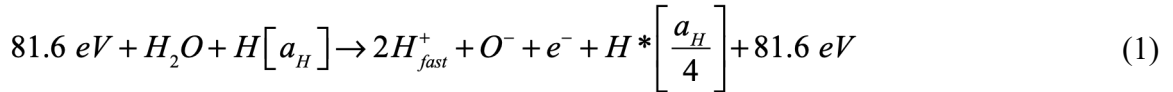
Abstract

A hydrino atom, $H(1/p)$ solved using a Maxwellian electrodynamics and relativistic mechanics, is atomic hydrogen with state energy $E_n = -13.598/n^2$ eV, in which $n = 1/p$, and p is limited by the energy in the electric field of the proton to 126 whereafter the proton and electron decay. Electron transitions to hydrino states involve an initial non-radiative energy transfer to a catalyst that serves as an energy hole or sink of a quantized amount of energy, $2mE_1$ (m is integer) to be transferred to a catalyst such as HOH, a free or nascent water molecule. Furthermore, hydrino atoms can react to form the corresponding diatomic molecule referred to as molecular hydrino $H_2(1/p)$. In contrast to molecular hydrogen (H_2), the molecular hydrino ($H_2(1/p)$) is paramagnetic with $S = 1/2$ comprising a paired and unpaired electron in the same MO wherein the lower energy state central field is provided by photons akin to gluons in nucleons in addition to the field of the protons. Due to its unique structure, $H_2(1/p)$ interacts with the neutrinos in the energy range of the cosmological neutrino background ($C\nu B$) as confirmed by the neutrino mediated observations of predicted fine structure, predicted high magnetic field Paschen Beck effect, large downfield shifts, temporal changes of EPR spectra due to accumulated changes in fine structure state populations, extraordinary broadened signals, zero order absorption occurring in the perpendicular and parallel modes, and the observation of magnetic dipole-dipole interactions of $H_2(1/4)$ - H_2 dimer requiring intramolecular angular momentum transfer from a neutrino excited fine structure state in $H_2(1/4)$ as well as unique temperature and matrix dependences of the EPR signals. EPR was used to detect and characterize the $C\nu B$ for the first time. The isotropic and parallel propagation nature of $C\nu B$ can be exploited for line of site telecommunications requiring no transmission power to transmit signals in any direction unattenuated and undispersed through any physical barrier, including the Earth.

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Introduction

Atomic hydrogen is predicted to form fractional Rydberg energy states $H(1/p)$ called "hydrino atoms" wherein $n = \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \dots, \frac{1}{p}$ ($p \leq 126$ is an integer) replaces the well-known parameter $n = \text{integer}$ in the Rydberg equation for hydrogen excited states. The transition of H to a stable hydrino state $H\left[\frac{a_H}{p=m+1}\right]$ having a binding energy of $p^2 \cdot 13.6 \text{ eV}$ occurs by a nonradiative resonance energy transfer of $m \cdot 27.2 \text{ eV}$ (m is an integer) to a matched energy acceptor [1]. The nascent H_2O molecule (not hydrogen bonded in solid, liquid, or gaseous state) may serve as a catalyst by accepting 81.6 eV ($m = 3$) to form an intermediate that decays with the emission of a continuum band with a short wavelength cutoff of 10.1 nm and energy of 122.4 eV [2]. The catalysis reaction ($m = 3$) regarding the potential energy of nascent H_2O is



And, the overall reaction is



After the energy transfer to the catalyst, an intermediate $H^*\left[\frac{a_H}{m+1}\right]$ is formed having the radius of the H atom and a central field of $m+1$ times the central field of a proton (e.g. $H^*\left[\frac{a_H}{4}\right]$ is the intermediate in Eq. (1) wherein $m = 3$, and H_{fast}^+ and H_{fast} refer to these species with excessive kinetic energy. The continuum radiation band at 10.1 nm and going to longer wavelengths and the fast H theoretically predicted for the HOH catalyzed transition of H to the lower-energy hydrogen or hydrino state $H(1/4)$ were confirmed by extreme ultraviolet spectroscopy [2] and high-resolution visible spectroscopy of selective and unique broadening of the H Balmer α line [2,3-27]. Further predicted H line inversion was confirmed by quantitative visible spectroscopy of H lines [28-30], plasma power was measured optically and with a bomb calorimeter [2, 31-33], power from solid fuels was measured in a commercial bomb calorimeter [34], energy of electrochemical cells was measured by integrating the electrical power over time [35-36], and the formation of $H_2(1/4)$ product of Eqs. (1-4) was also confirmed by gas chromatography (GC), electron

paramagnetic resonance (EPR) spectroscopy, Raman spectroscopy, electron beam excitation spectroscopy, X-ray photoelectron spectroscopy (XPS), Fourier transform infrared spectroscopy (FTIR), and other techniques [31-39].

Telecommunication Signal Encoding by Creating Variations in the Constant Cosmological Neutrino Background ($C\nu B$) Flux

Cosmological neutrinos have the same distribution as the cosmic microwave background radiation, which is isotropic to about a part million over the entire sky, and locally it is essentially perfectly isotropic. Cosmological neutrinos, like photons of the cosmic microwave background radiation, travel billions of light years to Earth. Consequently, from any given point of the universe corresponding to an axis of propagation, cosmological neutrino rays are essentially perfectly parallel in all directions and perfectly uniform in intensity in all directions. The universe provides a flux of about 10 trillion low energy cosmological neutrinos per second per square cm perpendicular to a given surface that have constant intensity, parallel rays of spin $\frac{1}{2}$ photons in all directions that are essentially unattenuated and undispersed even with propagation through the Earth. Consequently, the $C\nu B$ may serve as an equivalent to an infinity of utilizable constantly powered omnidirectional telecommunication laser beams of precisely the energy range needed for encoding and receiving telecommunication signals enabled by absorption and interactions with molecular hydrinos. The resulting variations of the otherwise constant neutrino flux are controlled by a transmitter-receiver pair to send and receive a time variable neutrino flux that encodes the telecommunication signals. In a specific example, at least one spin flip transition such as those comprising a band in an applied EPR magnetic flux range are allowed by coupling to at least one neutrino absorption transition. As one of two possible conventions, a one of a digital transmitted signal corresponds to causing an absorption of the constant $C\nu B$ flux resulting in an attenuated $C\nu B$ flux, and a zero of a digital transmitted signal corresponds to the absence of absorption of the constant $C\nu B$ flux. The time dependent change in the neutrino signal recorded by a receiver EPR instrument as a function of time at the transition energy or energies of the transmission records the ones and zeros signal along the line of sight between the transmitter and receiver to receive the corresponding information digitally encoded in the ones and zeros.

Neutrino communication uses massless, neutral neutrino photons to send messages through Earth or space, offering secure signals that pass through solid matter, ideal for deep-sea, underground, or interstellar communication as well as being a superior approach than that of EM signal transmission in general applications. Scientists have demonstrated [40-41] the transmission and reception of pulses comprising bunches of neutrinos that were decoding to the digital sending of the simple digital message "neutrino" using a particle accelerator (Fermilab's

NuMI) that created a focused beam of neutrinos by smashing 120 GeV protons into a target and a massive detector (MINERvA). However, this neutrino communication system is incredibly impractical, due to extremely low data rates (bits per second) due to neutrinos' rare interactions and the massive size and extreme cost of the equipment needed, typically requiring an international effort.

Molecular Hydrino Cross Section for Absorption of the Cosmological Background Neutrino ($C\nu B$) Flux

Baryons such as protons and neutrons are spin $\frac{1}{2}$ particles possessing current variation along three orthogonal axes corresponding to current along two orthogonal axes relative to a neutrino propagation direction as shown in Mills GUT the Proton and Neutron section [1]. The neutrino is a spin $\frac{1}{2}$ photon with a matching angular momentum and electric and magnetic field variation as the nucleons permitting neutrino absorption by these nucleons. Furthermore, Mills [1] gives the analytical solution of molecular hydrino such as $H_2(1/p)$ comprising a paired and an unpaired electron in a single molecular orbital (MO). The $H_2(1/p)$ MO forms from two $H(1/p)$ atoms wherein the two photons of the $2H(1/p)$ combine to form a single photon of total angular momentum $\hbar$ wherein the photon-induced surface currents on the dimensional prolate spheroidal current density membrane (MO) are equivalent to those of a paired and an unpaired electron in the same MO with a current density given by $\frac{1}{2}(\uparrow\uparrow + \downarrow\uparrow)$. The unpaired MO electron of $H_2(1/p)$ with a net electron spin of $\frac{1}{2}$ gives rise to spin flip transitions observed by electron paramagnetic spectroscopy (EPR) and well as magnetism observed by magnetic susceptibility measurements [32, 38-39]. The corresponding angular momentum projections of $H_2(1/p)$ MO are shown in Figures 1 and 2 wherein the MO behaves as if it was comprised of quarks and the photons as gluons of a nucleon permitting neutrino spin $\frac{1}{2}$ photons to be absorbed.

Figure 1. The z-axis view of the bound electron MO, a prolate spheroidal two-dimensional supercurrent comprising an extended continuous distribution of charge and current completely surrounding the nuclei at the foci, obtained by stretching $Y_0^0(\theta, \phi)$ along the semimajor axis wherein the surface that generates two orthogonal components of angular momentum having $L_z = \frac{\hbar}{2}$ along the z-axis and giving rise to the phenomenon of electron spin.

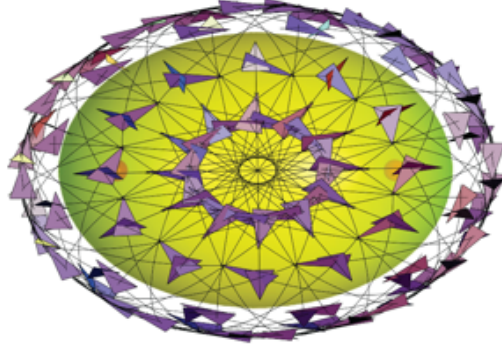
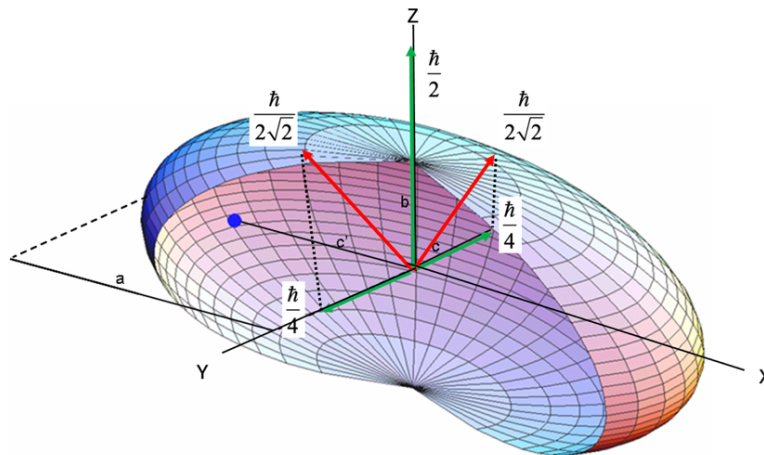


Figure 2. The MO that forms from two H(1/p) atoms wherein the two photons of the 2H(1/p) combine to form a single photon of total angular momentum $\hbar$ that supports surface currents on the dimensional prolate spheroidal current density membrane that have angular momentum components of $\frac{\hbar}{2}$ along the z-axis, $\frac{\hbar}{2\sqrt{2}}$ along the $(0\mathbf{i}_x, \mathbf{i}_y, \mathbf{i}_z)$ and $(0\mathbf{i}_x, -\mathbf{i}_y, \mathbf{i}_z)$ -axes, and yz-plane projections of the latter of $+\frac{\hbar}{4}$ along the $(\mathbf{i}_x, \mathbf{i}_y, 0\mathbf{i}_z)$ -axis wherein the corresponding angular momentum projections relative to the Cartesian coordinates are shown.



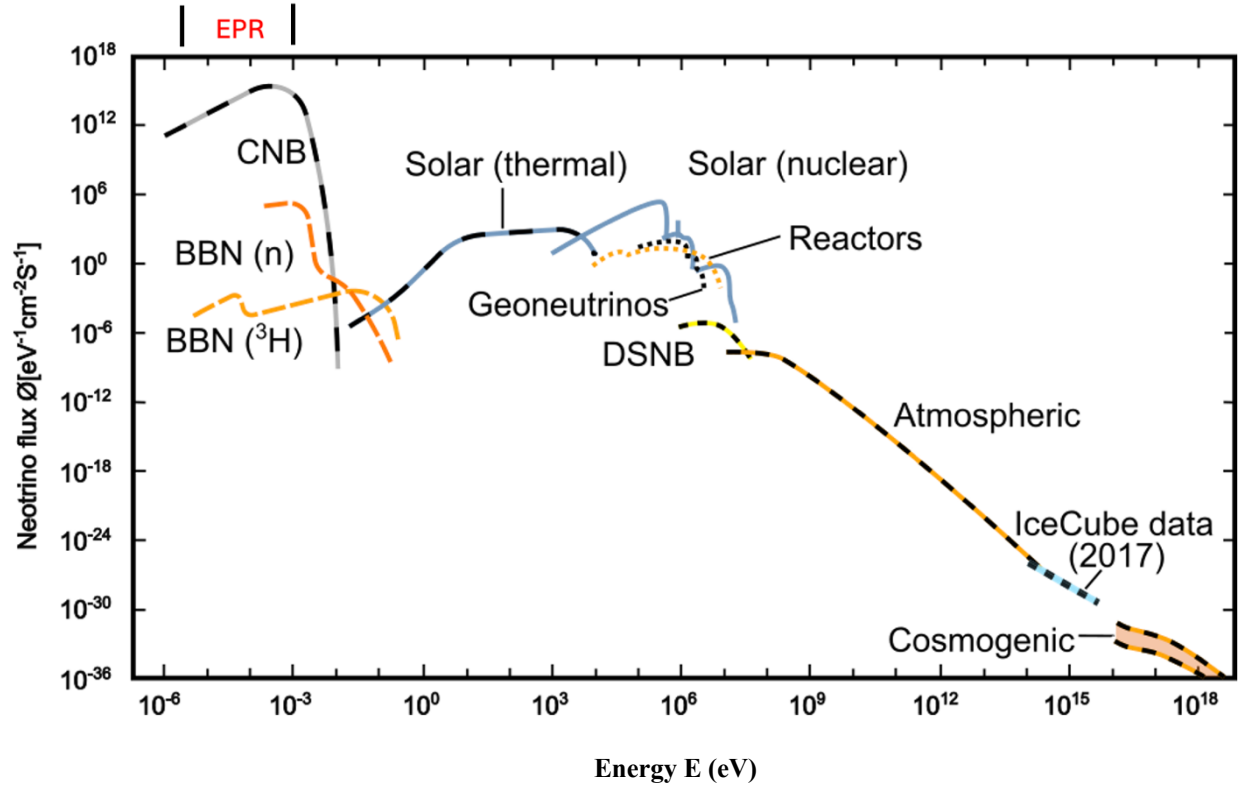
The geometric cross section of the spin $\frac{1}{2}$ hydrino molecular orbital for neutrinos comprising spin $\frac{1}{2}$ photons is about 8 orders of magnitude greater than that of a baryon. Nuclear-neutrino interactions occur at MeV energies and higher whereas neutrino-vibrational

excitation of $H_2(1/p)$ occurs at a threshold of about 2 eV and neutrino- $H_2(1/p)$, $[H_2(1/p)]_2$, and $H_2(1/p)$ - H_2 dimer interactions involving fine structure, fine structure with inter-dimer angular momentum transfer, magnetic dipole-dipole interactions of $[H_2(1/p)]_2$ dimers due to inherent and induced magnetic moments, van der Waals dipole charge redistribution of molecular hydrino dimers, and other energy shift mechanisms occur in the same energy range as electron paramagnetic spectroscopy (EPR) transitions, 10^{-5} to 10^{-4} eV. Thus, the corresponding energy dependency factor of the geometric cross section of the hydrino-neutrino interaction is between 10^{10} to 10^{20} times higher compared to nuclear-neutrino interactions wherein the neutrino geometric cross section is proportion to its wavelength squared. Thus, the cross-section for neutrino absorption by molecular hydrino approaches 28 orders of magnitude higher (i.e. 10^{28} times) than that of nuclei.

Cosmological neutrinos, also known as the Cosmic Neutrino Background or $C\nu B$, have a flux that is about 10^7 - 10^8 times higher than that of solar neutrinos (Figure 3) wherein their flux perpendicular to every direction of propagation has a peak intensity of about $1 \times 10^{13} \text{ cm}^{-2}\text{s}^{-1}$. The cosmological neutrinos have thermalized with the photons of the cosmic microwave background of 2.73 K comprising a blackbody profile corresponding to an energy of 2.35×10^{-4} eV such that cosmological neutrinos have very low energy (e.g. μeV -1meV range) when compared with solar neutrinos (~ 1 MeV). The energies of $C\nu B$ are about the same as those of electron spin-flip transitions recorded during EPR spectroscopy, (e.g. X-band (Most Common): ~ 9 -10 GHz (e.g. 9.5 GHz), requiring fields around 0.34 Tesla (3400 Gauss) corresponding to an energy of 3.93×10^{-5} eV. During a typical electron paramagnetic resonance (EPR) experiment the continuous microwave (CMW) power is on the order of 10 mW, and the power absorbed by the sample is extremely small, often being as low as the range of picowatts to nanowatts absorbed by the sample inside the resonator. The power per square centimeter of the cosmological background neutrino flux is given by the flux ($1 \times 10^{13} \text{ neutrinos cm}^{-2}\text{s}^{-1}$) times the energy $3.77 \times 10^{-23} \text{ J}$ corresponding to $3.77 \times 10^{-10} \text{ W cm}^{-2}$ of continuous power. In the case that the sample area is 1 cm^2 , the total power of the cosmological neutrino flux is 0.38 nW which is a detectable signal especially considering the selection rules for neutrino transitions that give rise to corresponding excited states that may possess extended lifetimes such that an inventory of molecular hydrino radicals with corresponding populated states accumulates. A plurality of technology options for neutrino telecommunications transmitters and receivers exist to transmit and receive a neutrino-absorption mediated signal that have very high response rates (e.g. GHz) and sensitivities to a single photon [42]. Some exemplary spin-transition detector technologies are discussed in the EPR detection of neutrino interaction with materials comprising hydrino section and the Transmitter and receiver technologies section. As a comparison a cell phone can receive a signal of 10^{-15} W . Moreover, there is essentially no interfering neutrino signal source in

the energy range of the CvB, and neutrinos are unattenuated in penetrating a Faraday cage enabling near total elimination of external electronic noise. Thus, the low-power limit for neutrino telecommunications signals may be orders of magnitude lower than those transmitted electromagnetically.

Figure 3. The CNB, C-Nu-B, or *CvB* (cosmological neutrino background) flux, solar neutrino flux, and the flux of other cosmic sources as a function of neutrino energy as well as the EPR transition energy range. (The EPR energy range is indicated at the figure's top). There is also a neutrino background window for neutrino absorption by $H_2(1/p)$ during ro-vibrational level excitation enabling neutrino signal transmission and reception in the range energy range 0.1 eV to 10 eV [42].



Molecular hydrino such as $H_2(1/4)$ comprises a paired and unpaired electron in a single molecular orbital (MO) that gives rise to spin flip transitions as well as fine structure transitions corresponding to spin orbital coupling between the paired and unpaired electrons and fluxon linkage transitions observed previously by EPR [38-39]. It was further reported previously [1, 38] that hydrino molecules such as $H_2(1/4)$ can form linear dimers (e.g. $[H_2(1/4)]_2$) by forming an end-to-end van der Waals bond between the two molecules of the dimer. The EPR spectrum undergoes energy shifts (i. e. resonant magnetic field shifts) of the unpaired electron spin flip transition due to sources of magnetic field other than that applied such as that arising from at

least one of an orbital magnetic moment, magnetic dipole-dipole interaction between members of a dimer, $H_2(1/p)$ fine structure level excitation, and perturbation to the van der Waals charge density distribution of the bond of molecular hydrino dimers that alters the intermolecular dipole field interaction. The energy shifts due to the magnetic field perturbations overlap the energy distribution of the $C\nu B$ (Figure 3). Neutrinos of the $C\nu B$ may be involved directly or indirectly in the alteration of the flux experienced by the unpaired electron of $H_2(1/p)$ as a monomer or dimer. Moreover, the energy of $C\nu B$ neutrino photons may provide energy for spin flip and other changes in the magnetism of material comprising hydrino molecules. Thus, neutrino absorption by hydrino molecules and molecular hydrino dimers can be recorded by the resulting change in the magnetic field of the species. Exemplary instruments to record the change in magnetic field due to neutrino-molecular hydrino and neutrino-molecular hydrino dimer interactions are a superconducting quantum interference device (SQUID) magnetometer and an EPR spectrometer.

EPR detection of neutrino interaction with materials comprising hydrino

A radio frequency (RF) SQUID—comprising a SQUID sensor inductively coupled to an RLC resonant tank circuit responds to magnetic flux applied to the device to function as an ultra-sensitive magnetometer used to measure incredibly weak magnetic fields. The RF SQUID system typically operates by inductively coupling the superconducting SQUID loop comprising two Josephson junctions that cause the loop to link flux in units of the magnetic flux quantum to a resonant RLC tank circuit wherein the SQUID acts as a variable, flux-dependent inductance. The RLC circuit is driven by an alternating RF current. Because the RLC circuit is coupled to the SQUID, any tiny, external magnetic field acting on the SQUID changes its effective inductance. This change shifts the resonant frequency and the impedance of the RLC circuit, which translates the magnetic field into measurable voltage variations. A molecular hydrino sample such as one comprising at least one of $H_2(1/p)$ and $[H_2(1/p)]_2$ inserted into the superconducting loop may serve to record the signal from the $C\nu B$ due to the interaction of these neutrinos with electrons spin transitions of the sample in the absence or presence of an applied magnetic field. An EPR instrument comprising a high frequency superconducting quantum interference (SQUID) device EPR detector such as one comprising a molecular hydrino species as part of the inductor of an RLC circuit may exploit the sensitivity of SQUIDS to detect electron spin flip transitions affected by neutrino interactions.

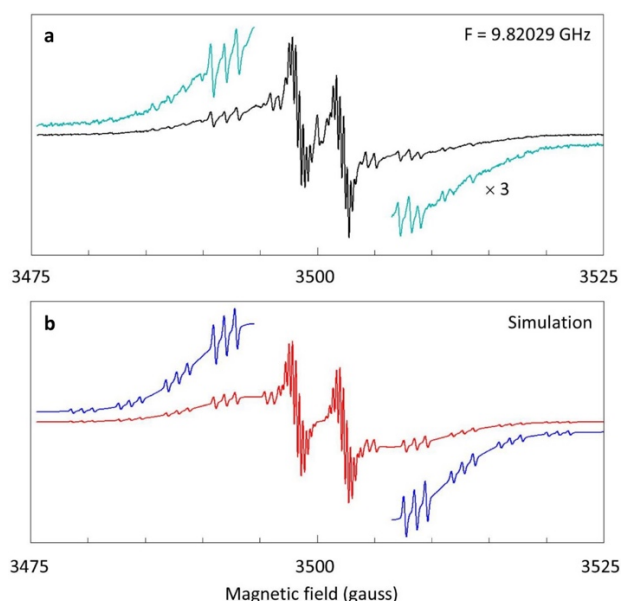
Similarly, an EPR spectrometer comprises an RF cavity wherein the spin-transition resonance is achieved by matching the magnetic field strength applied to the sample with applied RF power to cause the spin transition of the unpaired electron of molecular hydrino. Specifically, an electron paramagnetic resonance (EPR) spectrometer also behaves fundamentally as an RLC circuit coupled resonator that responds to magnetic flux at a resonance

condition between the applied flux and the energy of applied photons. The microwave cavity (or resonator) holding the sample acts as an RLC resonant circuit coupled to a transmission line, and it is additionally coupled to the precessing spins within the sample itself. The microwave field is stored in the resonator. The unpaired electrons of the sample act as a second, magnetic oscillator. When placed in an external magnetic field and excited by the microwave frequency, the spins exhibit a magnetic susceptibility. At resonance, the sample absorbs energy from the microwave magnetic field. This absorption adds a loss term to the equivalent RLC circuit, altering the cavity's Q-factor (quality factor) and impedance. Typically, the EPR cavity is excited at a fixed frequency characteristic of the cavity and the magnetic flux is scanned to achieve a resonance with the electron spins which cause a dip in the cavity power due to absorption by the electron spin transitions. The resonator is critically coupled, which means that the incident power is completely absorbed by the resonator. Additional absorption by the sample during resonance leads to a detuning of the resonator and reflection of microwave power. The measurement of this reflected microwave power as a function of the magnetic field yields the corresponding CW-EPR spectrum. Amplitude modulation of the magnetic field with a frequency of typically 100 kHz increases the signal-to-noise (S/N) ratio considerably and is responsible for the derivative shape of the spectra. The EPR instrument may perform as an RLC circuit coupled RF resonator wherein the loop of the circuit contains molecular hydrino that can interact with neutrino photons of the $C\nu B$ to cause a corresponding excited state current and magnetic flux to superimpose and shift the applied field to match the energy of the spin transition to that of the applied microwave power at applied cavity resonance frequency. Additional, spin-transition detector technologies are discussed in the Transmitter and receiver technologies section.

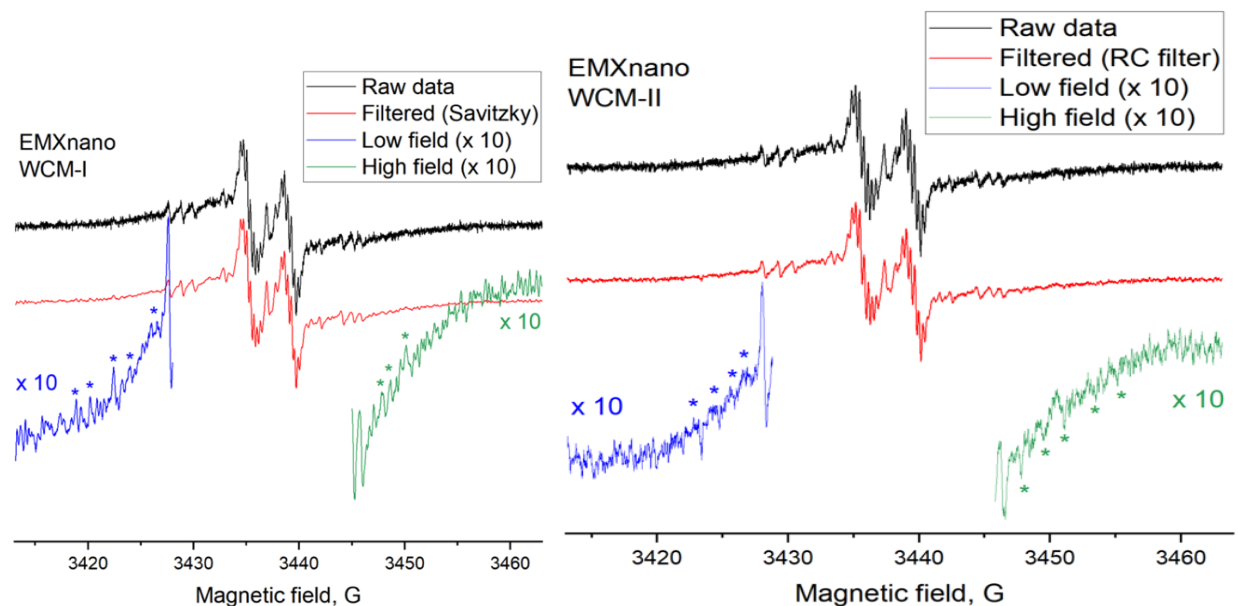
Molecular hydrino such as $H_2(1/4)$ comprises a paired and unpaired electron in a single molecular orbital (MO) that gives rise to spin flip transitions observed by electron paramagnetic spectroscopy (EPR). The $H_2(1/p)$ EPR spectrum possesses fine structure splitting due to spin orbital and fluxon linkage transitions that may couple with the spin flip transition of the unpaired electron of $H_2(1/p)$ wherein relativistic magnetic interactions between the paired and unpaired electrons of its MO give rise to the spin orbital splitting, and the linkage of flux in units of the magnetic flux quantum give rise to the fluxon linkage splitting of the spin flip transition peak. In addition to the possession of these fine structure levels, a source of excitation that matches the selection rules of the transitions is required. Neutrinos are spin $\frac{1}{2}$ photons that have a multipolarity that permits allowed spin-orbital transitions in isolated $H_2(1/p)$ molecules. Ga(O)OH was previously shown [39] to serve as a lattice that near-perfectly isolates individual $H_2(1/4)$ molecules that behave as if at near infinite vacuum condition. Due to the multipolarity of the transitions requiring neutrino excitation and decay and the near collisional lattice environment, the lifetimes of the spin-orbital states are anticipated to be long-live corresponding

to very narrow linewidths. The experimental EPR spectrum recorded on Ga(O)OH@H₂(1/4) comprising H₂(1/4) molecules isolated in a Ga(O)OH matrix is shown in Figure 4a. The H₂(1/4) molecules exhibited vacuum-like behavior wherein sharp, well resolved lines are assigned to neutrino excitation of the fine structure lines coupled with the spin flip transition of H₂(1/4). The first-principles-derived analytical solution of the theoretically predicted *g* factor for the spin flip transition with the predicted extraordinary features of a series of multiplets due to fluxon linkage within a series of multiplets due to spin-orbital splitting between the diamagnetic paired and paramagnetic unpaired electron of the MO during the EPR transition shown in Figure 4b matches the observed EPR spectrum within experimental error. The EPR spectrum was replicated by Bruker (Bruker Scientific LLC, Billerica, MA) using two instruments on duplicate samples as shown in Figures 5A-B.

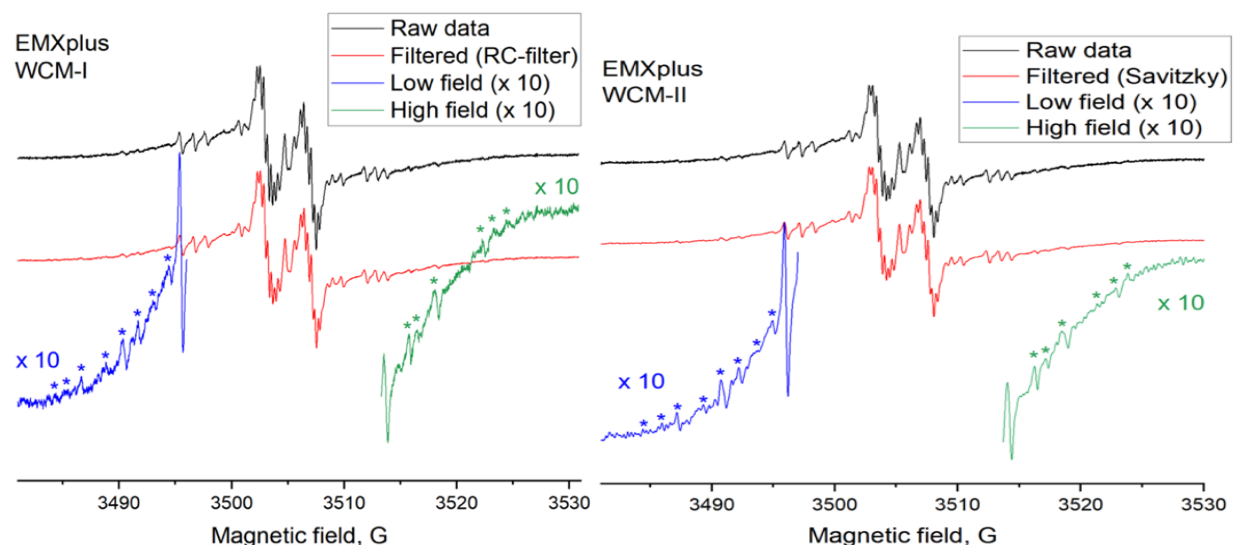
Figures 4a-b. The comparison of the EPR spectrum of Ga(O)OH:H₂(1/4) at high resolution comprising molecular hydrino H₂(1/4) in a Ga(O)OH matrix to that predicted by hydrino theory. **(a)** Extensively averaged spectrum (2400 min) taken under conditions optimized for maximal signal-to-noise ratio at the expense of minor over-modulation (0.2 gauss), exhibits a pattern of multiplets due to spin and orbital coupling between the paired and unpaired electrons of the H₂(1/4) molecular orbital further split into sub-multiplets due to magnetic flux linkage in integer multiples of $h/2e$. The source of excitation of these fine structure levels is assigned to *CvB* absorption. **(b)** The analytical solution of field positions predicted by hydrino theory using first principles.



Figures 5A-C. EPR spectra of $\text{Ga}(\text{O})\text{OH}:\text{H}_2(1/4)$ replicated by Bruker using two instruments on duplicate samples. (A) EMXnano data. (B) EMXplus data.



(A)



(B)

In Hagen and Mills 2024 [38], a large down-field singlet signature and temperature dependencies recorded by EPR were reported that confirm the theoretical prediction of the formation of molecular hydrino dimers $[\text{H}_2(1/p)]_2$ as an extension of ordinary hydrogen chemistry. H_2 is known to form dimers $[\text{H}_2]_2$ at cryogenic temperatures whereas $[\text{H}_2(1/p)]_2$ was shown to be stable at elevated temperatures. Unlike the free-gas $\text{H}_2(1/4)$ monomer spectrum of

Ga(O)OH@H₂(1/4) shown in high resolution in Figure 4a, the dimer [H₂(1/4)]₂ EPR spectra were very broad and downfield shifted by ~500 G (Figure 6). The results further showed the production of H₂(1/8) and [H₂(1/8)]₂ dimers having a greater downfield shift of ~4030 G (Figure 7).

Figure 6. Two very different types of EPR spectra were observed from molecular hydrino samples, Zn(OH)₂@H₂(1/4) prepared by Zn wire detonation in humidified air atmosphere (blue trace) [38] and Ga(O)OH@H₂(1/4) prepared by aqueous KOH treatment of gallium oxide collected following a plasma reaction in a SunCell [39] comprising molten gallium as one of the electrodes (red trace). The Zn(OH)₂@H₂(1/4) zero crossing was shifted -500 G downfield from the Ga(O)OH@H₂(1/4) peak at g = 2.0046.

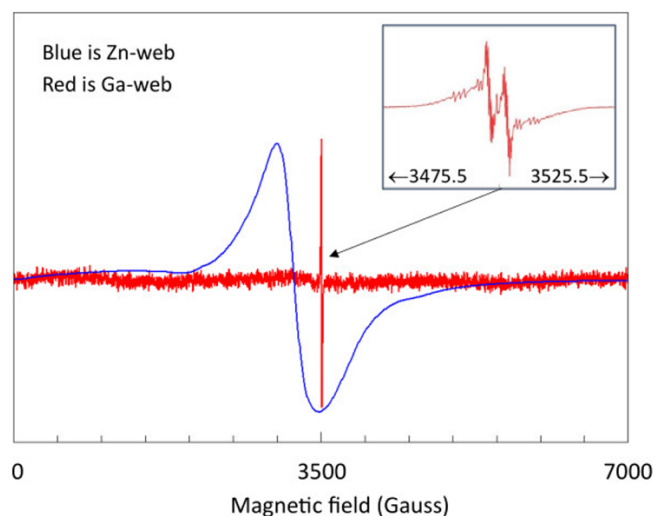
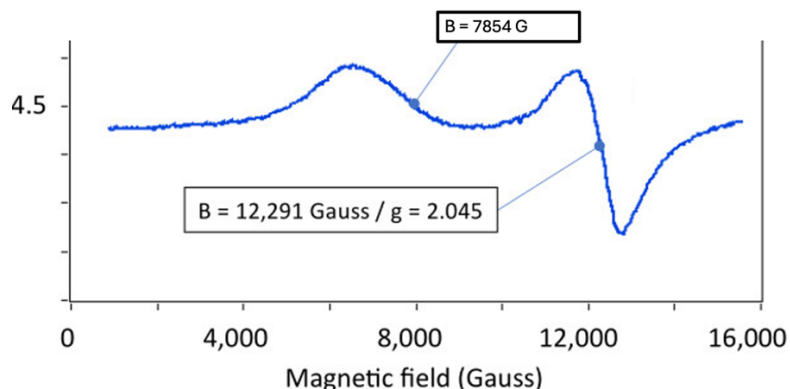
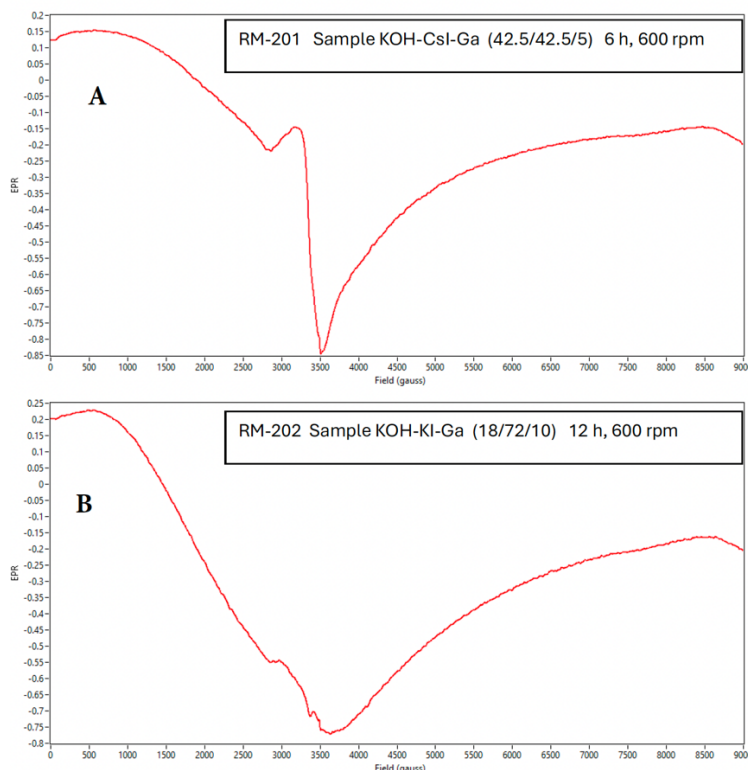


Figure 7. The formation of van der Waals bonded dimers of molecular hydrino was confirmed by the match between predicted and observed downfield shifted EPR peaks for the dimers $[\text{H}_2(1/4)]_2$ and $[\text{H}_2(1/8)]_2$ embedded in the matrix comprising ball milled $\text{NaHCO}_3/\text{NaCl}/\text{Ga}$ 47.5/47.5/5 wt% recorded at 35.19000 GHz. The positions of the zero crossing are indicated for $[\text{H}_2(1/4)]_2$ and $[\text{H}_2(1/8)]_2$ at $g = 2.045$ and $B = 7854$ G, respectively [38].



The EPR spectra of ball milled KOH-KI-Ga metal (18/72/10 wt%) and KOH-CsI-Ga metal (42.5/42.5/5 wt%) are shown in Figures 8A and 8B, respectively. Extraordinary broadening over an entire range of over 9000 G matching that of the CvB extending to zero field with the highest intensity of decreasing slope starting a zero field were observed in these and other samples comprising molecular hydrino formed by ball milling hydrino reaction mixtures. The broadening mechanisms caused by molecular hydrino and dimers that match observations are next considered. The mechanism of molecular hydrino and dimers giving rise to the zero field EPR signals is discussed in the Temporal changes in the zero field EPR of tin-hydrino samples section and the Dual-mode EPR section.

Figures 8A-B. The 0-9000 G EPR spectra of ball milled (A) KOH-KI-Ga metal (18/72/10 wt%) and (B) KOH-CsI-Ga metal (42.5/42.5/5 wt%) showing broadening over a vast range of over 9000 G extending to zero field with the highest intensity.



EPR was also performed at 275.7 GHz on the $\text{Zn(OH)}_2@\text{H}_2(1/4)$ sample formed by detonation of a Zn wire in a H_2O vapor atmosphere. As shown in Figure 9A, a broad peak was observed at 9.813 T that was assigned to $\text{H}_2(1/4)\text{-H}_2$ dimer having a predicted -131 G downfield shift as discussed in the $\text{H}_2(1/4)\text{-H}_2$ Dimer section. The downfield shifted $[\text{H}_2(1/4)]_2$ and $[\text{H}_2(1/8)]_2$ molecular hydrino dimer peaks were observed at the predicted shifts of -502 G at 9.78 T and -4028 G shift at 9.42 T, respectively. As shown in Figures 9A-B, a positive continuum intensity having a width of about 2000 G preceding each peak corresponding to an energy range of 6.5×10^{-5} eV was observed which matches molecular hydrino fine structure energy ranges and further matches the flux intensity profile of the cosmological background neutrino flux (Figure 3).

In addition, as shown in Figure 9B a very sharp triplet was observed having a center-line g factor of 2.00570 and 23 G splitting which is quite different from the complex $\text{H}_2(1/4)$ spectrum recorded on $\text{GaOOH}@\text{H}_2(1/4)$ at relatively low magnetic field strength (Figures 4a-b). A strong external magnetic field applied to a radical can give rise to the Paschen-Back effect, which leads to the decoupling of spin and orbital angular momentum (e.g. the transition from total angular momentum J to separate projections with corresponding orbital (m_L) and spin (m_S))

quantum numbers, respectively) [43]. The complex multi-line splitting seen in the weak-field fine structure Zeeman effect collapses into a much simpler pattern, typically an unshifted and symmetrically split triplet (resembling the normal Zeeman effect). However, in the case of $H_2(1/p)$, spin orbital coupling may also give to a rise to a slight downfield shift due to the linkage of the unpaired and paired electrons of its MO.

For a typical radical, the selection rules for spin orbital coupling can be changed by the applied strong magnetic field that decouples the spin and orbital angular momentum. In a weak field, the Zeeman effect occurs wherein the selection rules rely on the total angular momentum quantum number J , and the selection rules for spin-orbital coupling are $\Delta J = 0, \pm 1$ and $\Delta M_J = 0, \pm 1$. When the magnetic field overwhelms the internal spin-orbit interaction, J is no longer a valid quantum number. The spin S and orbital L angular momenta now precess independently around the external magnetic field. Consequently, the selection rules simplify and decouple to $\Delta m_L = 0, \pm 1$ and $\Delta m_s = 0, \pm 1$ [43].

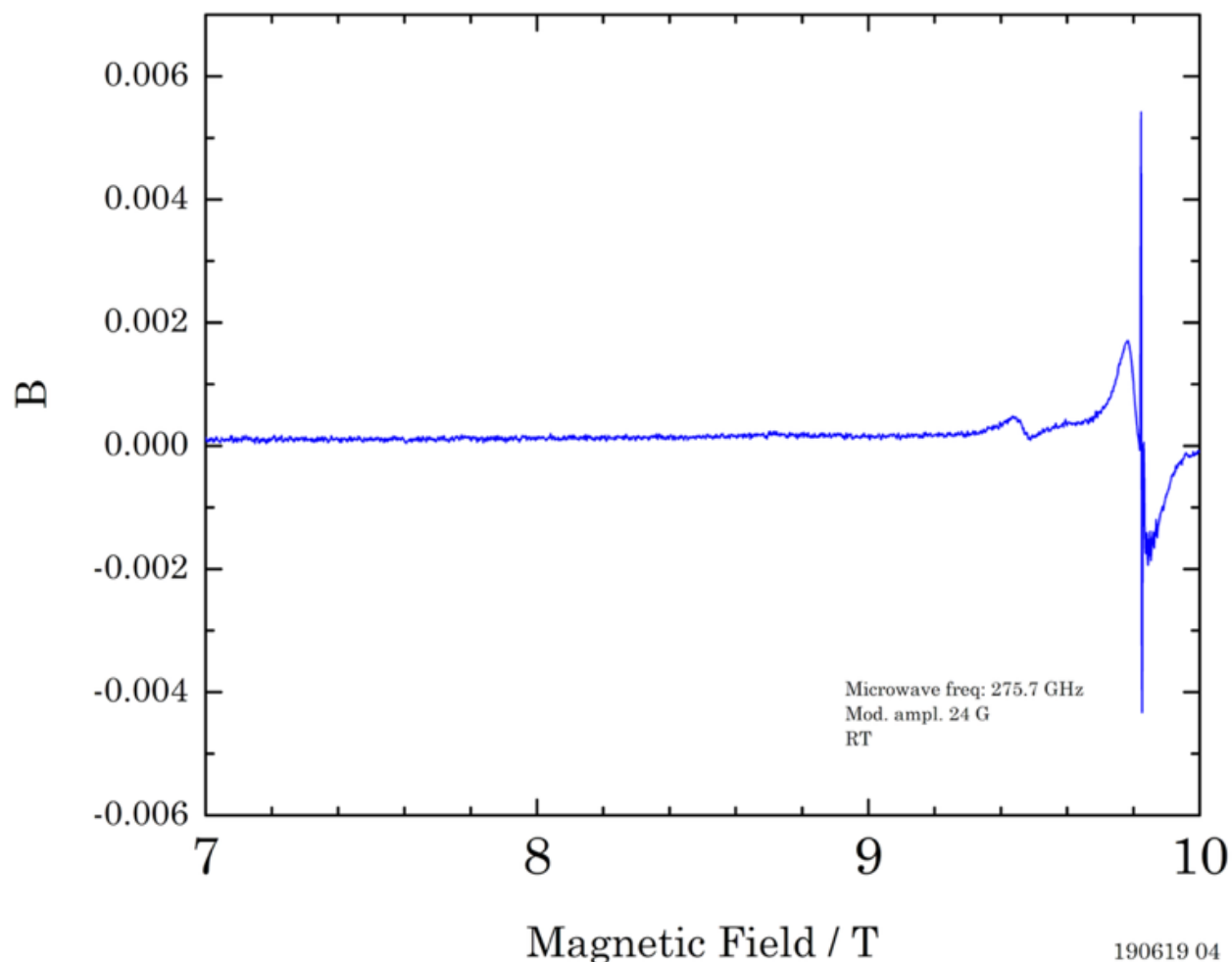
In the case of $H_2(1/p)$, the resulting energy of the spin flip transition with an applied strong magnetic field is calculated using the sum of the magnetic spin flip plus the contribution due to orbital angular momentum which effectively shifts the g factor downfield wherein in the orbital magnetic moment of the unpaired electron of the $H_2(1/4)$ MO effectively adds a contribution to the electron spin g factor given by Mills Eqs. (16.225) and (16.226). The relativistic flux provided by the electron spin during spin-orbital coupling between the paired and unpaired electrons (Mills Eqs. (15.233-16.235)) is replaced by the lab frame flux B requiring a relativistic correction to the magnetic susceptibility of the unpaired electron (Mills Eq. (16.234)) given by the reciprocal of Eq. (1.181) corresponding to the transition from the light-like frame to the lab frame. Furthermore, according to Eq. (16.233), the projection of the applied B flux to the orbital angular moment is corrected by $\sqrt{\frac{3}{4}}$. The resulting g factor is

$$g_{H_2(1/p)} = 2 \left(1 + 2 \left(\frac{\alpha}{2\pi} + \frac{2}{3} \alpha^2 \left(\frac{\alpha}{2\pi} \right) - \frac{4}{3} \left(\frac{\alpha}{2\pi} \right)^2 \right) + \frac{2\pi}{\alpha} \chi_m \sqrt{\frac{3}{4}} \right) \\ = 2.0046386 + 3\pi\mu_0 \left(4 - \sqrt{2} \ln \frac{\sqrt{2} + 1}{\sqrt{2} - 1} \right) \frac{pe^2}{36a_0m_e} (1 + p\alpha^2) = 2.005695$$

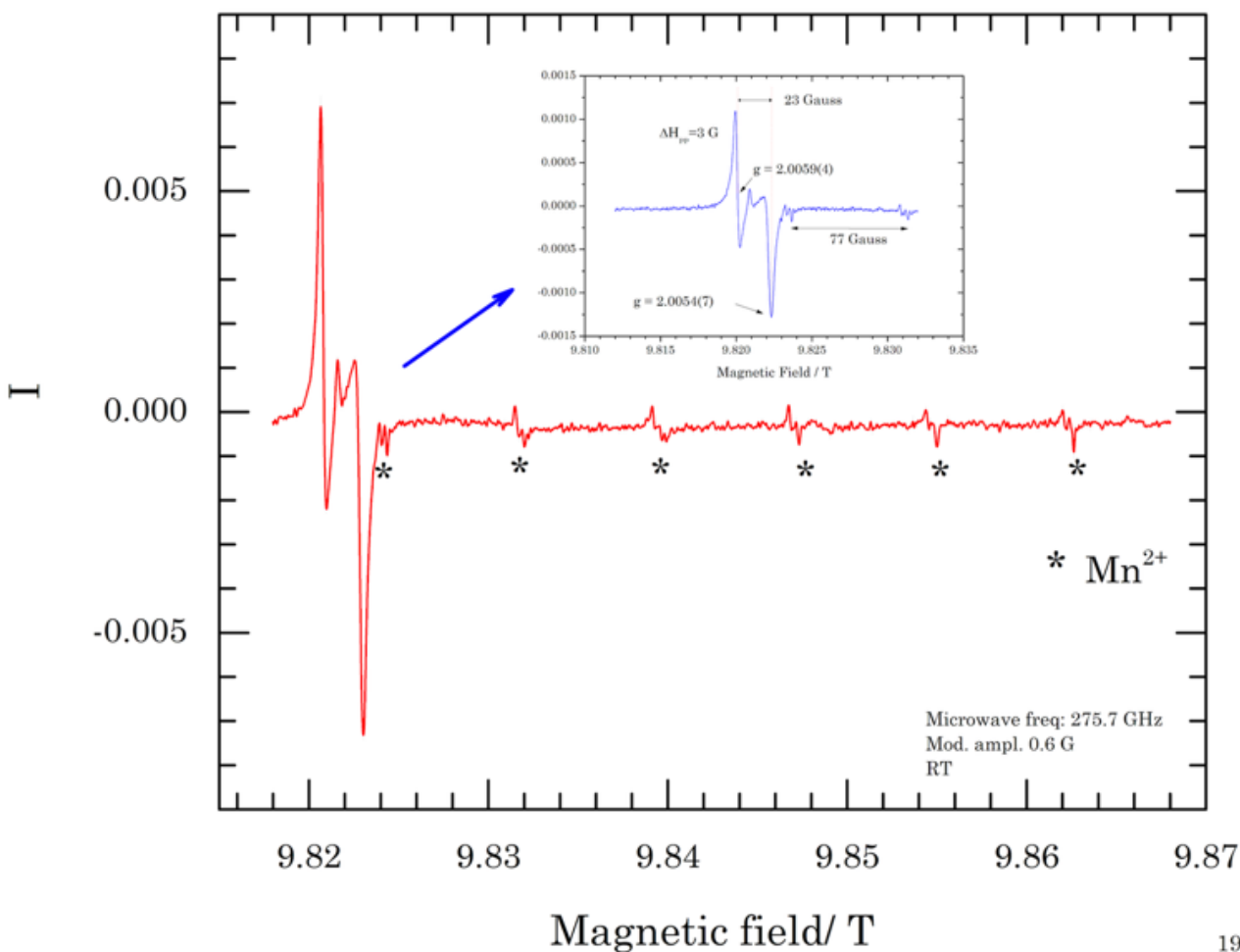
which matches very well with the 2.00570 g factor of the center line of triplet shown in Figure 9B. In addition to the external orbital splitting the internal spin orbital coupling splitting gives rise to the classical triplet in a strong magnetic field wherein the allowed quantum number for the neutrino affected spin-orbital transition is $\Delta m = \pm 2$ which is added to the concerted angular momentum change of $\Delta m = \pm 1$ during the spin-flip transition corresponding to a mixed state with $\Delta m = \pm 3$ and a splitting of 24 G given by Mills Eqs. (16.235) and (16.238) which compares

well with the 23 G splitting shown in the Figure 9B. The change in the selection rules with magnetic field strength changes the EPR spectrum and may be exploited to change the corresponding neutrino interaction such as the absorption of neutrinos to excite spin-orbital coupling transitions to at least one of transmit and receive telecommunication signals carried by the $C\nu B$.

Figures 9A-B. The EPR spectrum of the $\text{Zn}(\text{OH})_2 @ \text{H}_2(1/4)$ detonation product recorded at 275.7 GHz showing a slightly downfield shifted sharp $\text{H}_2(1/4)$ triplet peak and the broad downfield shifted $\text{H}_2(1/4)\text{-H}_2$, $[\text{H}_2(1/4)]_2$, and $[\text{H}_2(1/8)]_2$ molecular hydrino dimer peaks that are broadened by about 2000 G by neutrino fine structure absorption. A. 7 T to 10 T EPR spectrum. B. 9.814 T to 9.87 T EPR spectrum.



(A)



(B)

The intensity of the EPR signal corresponding to the magnitude of the absorbed power is directly proportional to the number of unpaired electrons (spins) actively undergoing resonance transitions. Applying too much incident power or the possession of a long relaxation time by the species comprising an unpaired electron can "saturate" the spins. When the absorption rate exceeds the rate at which excited electrons can relax back to their ground state, the energy levels equalize, and the absorption signal drops. The neutrino excitation of $[\text{H}_2(1/p)]_2$ may also decay following the absorption of the RF photon that transitions the molecular hydrino to a higher energy state. Unlike the case of diamagnetic $\text{Ga}(\text{O})\text{OH}$ lattice that isolate individual $\text{H}_2(1/4)$ monomers, dimers such as $[\text{H}_2(/4)]_2$ entrapped in alternative matrices may possess fast relaxation mechanisms which give rise to broadened EPR peaks. The spin decay lifetime of the molecular hydrino dimers influence the potential intensity of the spectrum wherein excited states with a

very short lifetime avoid saturation of the neutrino- $[H_2(1/4)]_2$ interaction and allow the detection of telecommunication pulses of high signal rate.

The spin lattice relaxation time, T_1 regards the lifetime of EPR excited state radicals following absorption of RF photons. It is typically in the ns to us range for molecules and is further dramatically shortened in the presence of paramagnetic ions such as oxygen and iron ions. Due to the intrinsic closely juxtaposed free electrons and the van der Waals electric dipole interactions, the molecular hydrino dimer is predicted to have a very short spin-flip relaxation time. Higher temperatures also drastically shorten T_1 . For example, T_1 at 10 K and at room temp can easily differ by 8 orders of magnitude. $S = 1/2$ systems may relax via a Raman mechanism that is proportional to T^9 . The extraordinary thermal stability of the dimers (e.g. $[H_2(1/4)]_2$) is permissive of operating at high temperatures. In addition, at cryogenic temperatures, the operating frequency may be increased to shorten T_1 (e.g., X-band vs. W-band) since the direct relaxation mechanism is effective at cryogenic temperature and scales with the fourth power of the resonance frequencies when the density of phonon states is dominated by frequencies corresponding to the EPR frequency. The lifetime of transitions involving neutrino excitation such as ones involving fine structure transitions may be made short (e.g. by coupling with the spin-flip transition) to permit transmission of telecommunication signals at a fast rate while avoiding signal saturation. A comparison of the dramatic difference in peak widths of isolated $H_2(1/4)$ monomers versus $H_2(1/4)$ existing as dimers wherein many fast relaxation mechanisms may be in effect as a contributing broadening factor is shown in Figure 6

The Lorentzian line width of the single EPR transition of $[H_2(1/4)]_2$ is anticipated to be much greater than that of $H_2(1/4)$ due to the requirement of the excitation field acting over the dimensions of the dimer electron current. The lifetime of the $[H_2(1/4)]_2$ EPR transition was previously calculated to be 1.70×10^{-10} s [38]. The corresponding frequency is 5.90×10^9 s⁻¹, and the energy width given by Planck's constant bar times the frequency is 6.22×10^{-25} J. For a g factor of 2.0046386 [1,39], the energy line width in Gauss is 335 Gauss which is the natural width (Eqs. (16.259-16.261) of [1]). The natural line width is the minimum line width that may be broadened by other mechanisms such as instrument, lattice collisional, Doppler, van der Waals, Stark, resonance, inhomogeneous, and dipole broadening. Many broadening mechanisms increase with temperature. A short state lifetime with a corresponding broad natural width of a transition may be accentuated by neutrino mediated spin-orbital coupling and close-proximity magnetic dipole dimer interactions wherein these and other broadening mechanisms may increase with temperature.

State lifetimes only change the natural width of a transition which is much less than that observed, particularly in the case of $[H_2(1/4)]_2$ dimers. Perturbations of the charge distribution of a hydrino species such as $H_2(1/p)$ comprising a monomer or comprising a hydrino molecule of a

dimer shifts the EPR spectrum of its unpaired electron. The absorption of a photon causes a time dynamic current density wave of the $H_2(1/p)$ molecular orbital such as one comprising a spheroidal harmonic as given in Chp. 12 of Mills GUT [1]. Depending on the incident photon multipolarity, an excited state photon propagates an orbital current and corresponding orbital angular momentum and orbital magnetic moment. Additionally, absorbing a photon to form an excited state molecule can significantly increase van der Waals bonding. This phenomenon, known as Optical van-der-Waals forces, can create forces that are significantly stronger and act at longer ranges than standard nonexcited-state dispersion forces. Specifically, the excited state molecule will often possess a permanent electric dipole moment during the excited state lifetime. Based on the selection rules for the transition, the MO charge density rearranges into different spatial orbitals due to the exciting photon and the resulting MO having a matching asymmetric distribution. The excited state induced permanent electric dipole moment may superimpose the van der Waals electric dipole of a molecular hydrino dimer and alter the van der Waals force. Consequently, the intramolecular distance will be altered to be smaller or greater causing an increase or decrease in the magnetic dipole interaction between the two hydrino molecules and thereby cause a shift in the EPR spectrum downfield or upfield, respectively.

Neutrino interaction with $H_2(1/4)$ monomers and dimers also shifts the EPR spectrum to corresponding novel resonance peaks. Neutrino- $[H_2(1/p)]_2$ interaction requires the creation of a transition involving an energy change during excitation. The interaction may be detected by an EPR spectrometer when the interaction energy couples with the resonance spin flip transition energy by altering the magnetic field experienced by the unpaired electron of a molecular hydrino monomer. Two hydrino molecules are bound along the semimajor axis (end-to-end) by van der Waals induced electric dipole bonding to form a dimer. The formation of a molecular hydrino dimer creates an electric dipole. A significant energy perturbation to the electron spin transition involves the change in the van der Waals dipole by the alteration of the electron surface charge density distribution by the absorption of a neutrino photon. An increase (decrease) in the dipole interaction by the absorption of a neutrino photon may cause a reduction (increase) in the dimer intermolecular distance that increases (decreases) the magnetic flux of one molecule relative to the other, causing a downfield (upfield) shift in the EPR applied magnetic field at the resonance condition of the applied RF frequency.

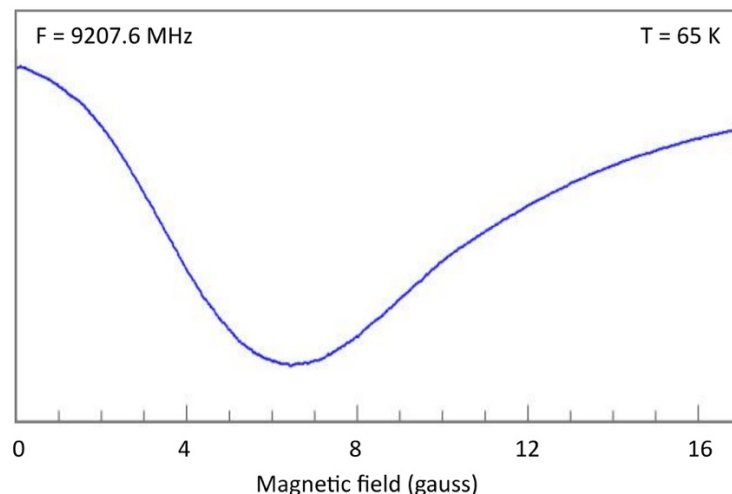
In addition, the neutrino photon can be absorbed by a hydrino molecule of a dimer to create a surface current that may at least partially unpair the paired electron or at least partially pair the unpaired electron (e.g. partial oriented triplet state) to increase or decrease the spin flip transition energy. The neutrino photon excited state electron current may comprise an orbital current and corresponding orbital magnetic moment. The magnetic flux of the orbital magnetic moment may superimpose an applied EPR magnetic field, either positively or negatively to

increase or decrease the total magnetic field applied to the free electron of the molecular hydrino. One mechanism involves the absorption of a neutrino photon by a hydrino molecule of a dimer to cause a spin-orbital coupling transition followed by intramolecular angular momentum transfer with angular momentum conservation to the partner molecule of the dimer. Intermolecular transfer of angular momentum may increase the corresponding orbital magnetic moment produced in the molecule that acquired the increased orbital angular momentum, thereby increasing the magnetic dipole-dipole interaction energy between members of the dimer comprising molecular hydrino. The increased interaction may give rise to an increased EPR shift which could be substantial (e.g. >1000 G) according to Mills Eq. (16.252) [1]. The formation of multimers beyond dimers may further give rise to large EPR shifts due to coupled magnetic dipole-dipole interactions.

Furthermore, the dimer can undergo vibrational and librational transitions, directly or indirectly excited by the hydrino-neutrino interactions wherein the latter case the excitation is mediated through a change in the van der Waals dipole strength. In addition, current corresponding to spin and orbital angular momentum in the presence of the applied EPR magnetic flux or another source may give rise to an electric field that can interact with the intrinsic molecular quadrupole moment and one that may arise due to van der Waals interaction between members of dimers comprising at least one hydrino molecule. The van der Waals electric dipole, spin-orbital, dimer vibrational and librational energies, and quadrupole energies may further superimpose or interact with intrinsic fine structure energies of the isolated $H_2(1/p)$ monomer such as corresponding to spin orbital coupling of the paired and unpaired electrons and fluxon linkage EPR transition energies to result in state energies that are so closely spaced that a continuum absorption is observed between EPR dipole and neutrino interaction absorptions.

A liquid matrix also dramatically increases the broadening of the EPR spectral lines due to a continuum of interactions such as rapid tumbling and collisions with highly mobile surrounding molecules to any given one undergoing an electron spin flip or spin-orbital coupling transition. $H_2(1/4)$ was liberated with HCl addition to ball-milled FeOOH under argon and condensed in a helium flow dewar to provide liquified $H_2(1/4)$ as for EPR analysis shown in Figure 10. Extraordinary broadening was observed such that the EPR signal was observed over the entire range of 0 to 17,000 G. Since the CvB , is a continuum spectrum and the magnetic flux is scanned continuously, the signal due to molecular hydrino-neutrino interactions may also comprise a continuum.

Figure 10. The 0-17,000 G EPR spectrum of cryogenically condensed $\text{H}_2(1/4)$ gas collected from ball milled FeOOH comprising $\text{Fe}_2\text{O}_3@ \text{H}_2(1/4)$ by acid reaction wherein the spectrum was recorded at 9207.6 MHz at 65 K. The peak was broadened to cover the entire scanned range of 17,000 G.



EPR of $[(\text{H}_2(1/4))_2]$ dimer in diverse matrices originally comprising a source of H and HOH catalyst to form hydrinos

It is well known (e.g. percussion detonation of energetic materials) that ball milling can drive chemical reactions by breaking bonds, heating, and providing activation energy [44]. Mixtures of compounds that provide a source of H and HOH catalyst to form $\text{H}_2(1/4)$ were ball milled to serve as EPR samples comprising various product matrices and $\text{H}_2(1/4)$ yields. EPR was performed on FeOOH and a series of chemical mixtures shown in Table 1 that were ball milled to produce $\text{H}_2(1/4)$, and X-band spectra were recorded at 9.4-9.9 GHz with a Bruker EMX-plus spectrometer using the high-sensitivity ER4119HS resonator as described in the Material and methods section and previously [37-38].

Ball milling FeOOH forms $\text{H}_2(1/4)$ since it serves as a source of H and HOH catalyst to form $\text{Fe}_2\text{O}_3:\text{H}_2(1/4)$. The EPR spectrum of ball milled FeOOH shown in Figure 11 is compared to the EPR of the FeOOH starting material. Other possible iron oxides such as Fe_3O_4 , Fe_2O_3 , and FeOOH were ruled out as present in significant abundance by an observed spin concentration (doubly integrated intensity between 0 and 9000 G) increase of a factor of circa 46 of the ball milled (i.e. $\text{H}_2(1/4)$) sample and the much broader peak of the $\text{H}_2(1/4)$ sample compared to the oxide control samples. Fe_3O_4 was further eliminated as a product by the observation of a constant signal intensity as a function of temperature in the range 7K to 293K. Other samples comprising dimers $[\text{H}_2(1/p)]_2$ (Figure 6) also showed a predicted dimer shift of 500 G and extraordinary peak broadening [1,38]. The embedding of $[\text{H}_2(1/p)]_2$ in the magnetic matrix of

Fe_2O_3 extraordinarily broadened the $[\text{H}_2(1/p)]_2$ EPR peak to 9000 G with shift of -500 G downfield relative to $\text{H}_2(1/4)$ at $g = 2.0046$ given in Figure 6 as shown in Figure 11.

Figure 11. $[\text{H}_2(1/p)]_2$ EPR spectrum of $\text{Fe}_2\text{O}_3:\text{H}_2(1/4)$ showing the predicted extreme downfield shifted and broadened peak.

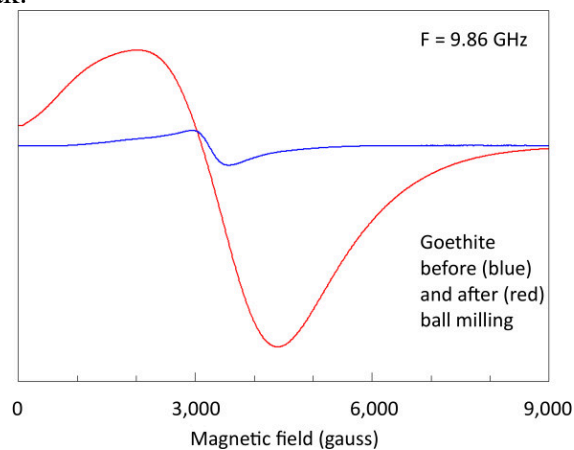


Table 1. Mixtures of compounds that provided a source of H and HOH catalyst to form $H_2(1/4)$ when ball milled to serve as EPR samples.

Sample ^a #	Sample composition	Duration (h)	Comments
1	KOH-KI (10/90 wt%)	3	
2	KOH-KI-Ga (10/80/10 wt%)	3	dark and released high-pressure gas
3	KOH-ZnO-Ga (10/80/10 wt%)	3	dark and released high-pressure gas
4	KOH-KI-Mg (10/80/10 wt%)	3	dark, some Mg thinned foil remaining
5	KOH-KI-In powder 325 mesh 99.99% (10/80/10 wt%)	3	
6	KOH-KI-Zn (10/80/10 wt%)	3	gray and released some gas
7	KOH-KBr-Ga (10/80/10 wt%)	3	dark and released some gas
8	KOH-KBr-Mg (10/80/10 wt%)	3	gray, some Mg thinned foil remaining
9	KOH-KBr-In powder 325 mesh 99.99% (10/80/10 wt%)	3	gray, released some gas
10	KOH-KBr-Zn (10/80/10 wt%)	3	gray, released some gas
11	KOH-ZnO-Mg (10/80/10 wt%)	3	gray and released some gas, some Mg thinned foil remaining
12	KOH-ZnO-In powder 325 mesh 99.99% (10/87/3 wt%)	3	yellow
13	KOH-ZnO-Zn (10/80/10 wt%)	3	black, burned in air and changed to yellow
14	Cu(OH) ₂ -KI-Ga (10/80/10 wt%)	3	reddish brown
15	Cu(OH) ₂ -ZnO-Ga (10/80/10 wt%)	3	extremely black, released some gas, magnetic
16	FeBr ₂ -Cu(OH) ₂ -KI (25/25/50 wt%)	5	reddish
17	FeBr ₂ -Cu(OH) ₂ -ZnO (25/25/50 wt%)	5	yellow, brown, reddish
18	Cu(OH) ₂ -ZnO-KI-Ga (10/40/40/10 wt%)	5	black, released some gas
19	Cu(OH) ₂ -KOH-ZnO-Ga-Zn (5/5/80/5/5 wt%)	5	black, released some gas
20	Cu(OH) ₂ -ZnO-Zn (10/80/10 wt%)	4	black, highly magnetic
21	Cu(OH) ₂ -ZnO-Mg (10/80/10 wt%)	4	black
22	ZnO-Zn (90/10 wt%)	4	black, highly magnetic
23	Zn(OH) ₂ -ZnO-Zn (10/80/10 wt%)	4	black, released some gas, highly magnetic
24	FeOOH-ZnO (10/90 wt%)	4	gray, highly magnetic
25	FeOOH-ZnO-Ga (10/80/10 wt%)	4	black, released some gas, highly magnetic

^a all samples were run at 600 RPM.

The neutrino absorption peaks recorded by EPR may be shifted by selection of the matrix comprising embedded molecular hydrino such as at least one of $H_2(1/4)$ and $[H_2(1/4)]_2$ embedded in an exemplary ZnO matrix (e.g. $ZnO@H_2(1/4)$) or a KOH, KI, and Ga matrix. The

EPR spectra of samples 1 through 3, 4 through 6, 7 through 15, and 16 through 25 of Table 1 are shown in Figures 12, 13, 14, and 15 respectively. All samples exhibit broad EPR spectra over the entire 0-9000 G range, but amplitudes vary widely. $\text{FeBr}_2\text{-Cu(OH)}_2$ was previously reported as a hydrino solid fuel [34] as ZnO serves as an effective getter for $\text{H}_2(1/4)$. FeOOH was also reported as a solid fuel (e.g. samples 24 and 25) [34,37]. Spectra of samples identified as highly magnetic in Table 1 (samples 20, 22, 23, 24, 25) all exhibit large downfield shifts. The spectra extended into the zero field and in some cases showed a negative slope at zero field indicating high intensity spin flip transitions with no field applied. This observation together with the extraordinary broadening is attributed to neutrino absorption and interactions by the mechanisms discussed *supra*. Additional structure was observed in the spectra of samples having the sample number underlined in Figure 15. By processing third derivative spectra, these features were identified to be due to $\text{H}_2(1/4)\text{-H}_2$ dimer as reported in the $\text{H}_2(1/4)\text{-H}_2$ Dimer section.

Samples 20, 22, and 23, were observed to be highly magnetic approaching ferromagnetic; yet comprised diamagnetic matrices. Due to the diamagnetic nature of the matrix the high magnetism was assigned to a high concentration of $\text{H}_2(1/p)$ species embedded in the sample. Materials comprising molecular hydrino may serve as a source of ferromagnetic material comprising super magnets to replace rare earth magnets. Due to the small size of $\text{H}_2(1/p)$ (e.g. 64 times smaller than H_2 in the case of $p = 4$) the packing density of the $\text{H}_2(1/p)$ can be orders of magnitude greater than that of rare earth magnets with a corresponding increase in magnet strength at about 100 times lower weight.

Figure 12. The 0-9000 G EPR spectra of samples 1 through 3 of Table 1 recorded at 9778 MHz. The relative amplitudes of the EPR signals are indicated. The top, middle, and bottom spectra correspond to samples 1, 2, and 3, respectively. The very broad peak observed at about 3000 G was assigned to $[\text{H}_2(1/4)]_2$ and the narrow peak at 3480 G was assigned to $\text{H}_2(1/4)$.

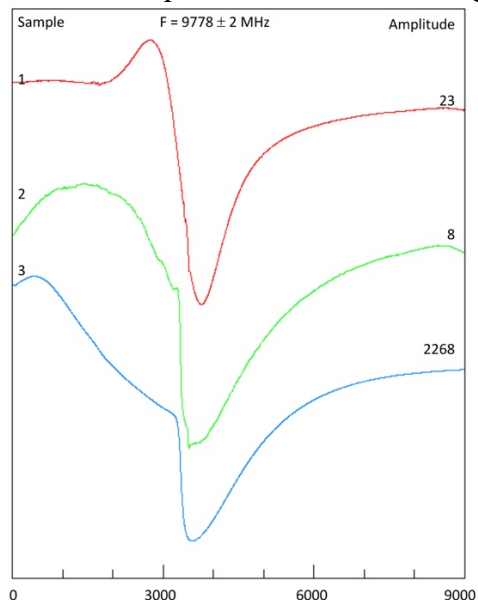


Figure 13. The 0-9000 G EPR spectra of samples 4 through 6 of Table 1 as well as tin, KOH, and KI control spectra recorded at 9782 MHz. The very broad peak observed at about 3000 G was assigned to $[\text{H}_2(1/4)]_2$ and the narrow peak at 3480 G was assigned to $\text{H}_2(1/4)$.

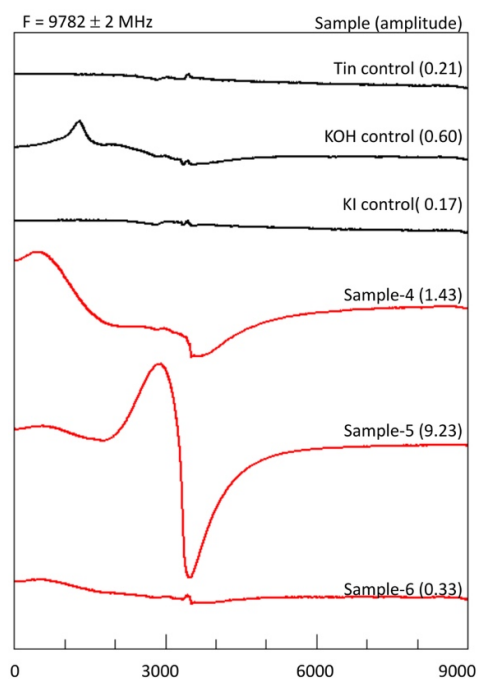


Figure 14. The 0-9000 G EPR spectra of samples 7 through 15 of Table 1 as well as ZnO and Cu(OH)₂ spectra recorded at 9782 MHz. The sample numbers are indicated on the left, and the relative amplitudes of the EPR signals are indicated on the right. The very broad peak observed at about 3000 G was assigned to [H₂(1/4)]₂ and the narrow peak at 3480 G was assigned to H₂(1/4).

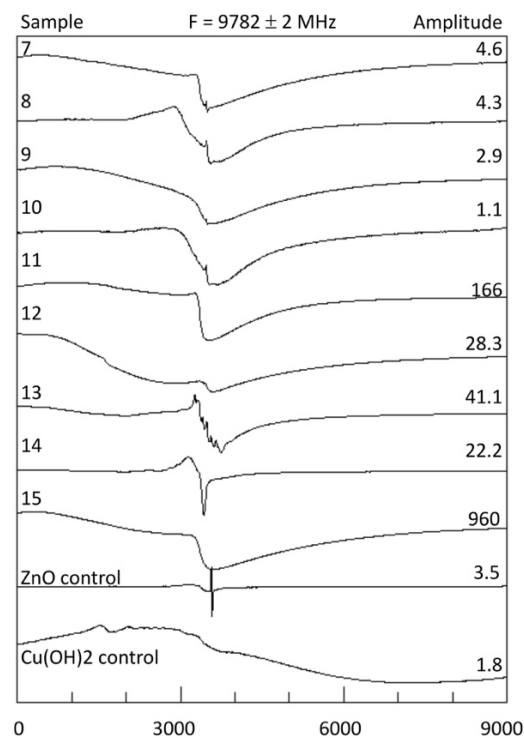
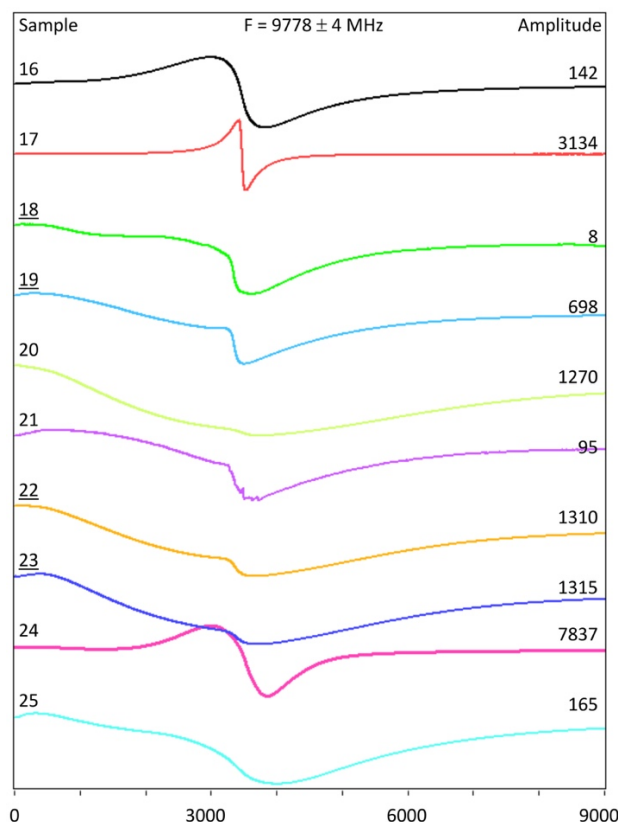


Figure 15. The 0-9000 G EPR spectra of samples 16 through 25 of Table 1 recorded at 9778 MHz. The sample numbers are indicated on the left, and the relative amplitudes of the EPR signals are indicated on the right. The very broad peak observed at about 3000 G was assigned to $[H_2(1/4)]_2$ and the narrow peak at 3480 G was assigned to $H_2(1/4)$. The third derivative EPR spectra of the sample numbers that are underlined is shown in Figure 20.



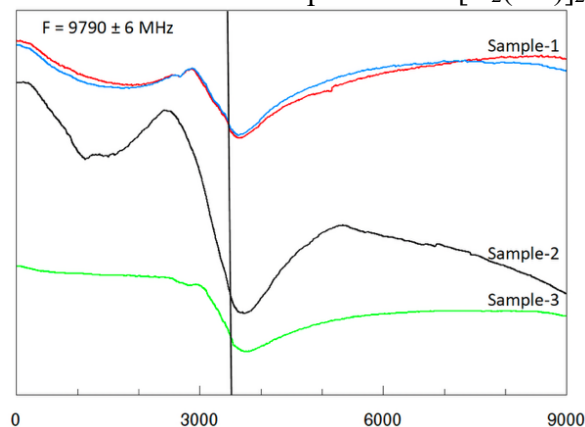
Temporal changes in the zero field EPR of tin-hydrino samples

The cross-section and corresponding intensity may be significant at zero field where the neutrino-excited molecular hydrino transitions are allowed and capable of matching the applied RF energy over a broad continuum range of applied magnetic flux due to the broad continuum energy $C\nu B$ spectrum that matches the typical energy range of the EPR X-band. The zero and low-field EPR signal intensity may be greatest wherein the difference between the spin flip energy of a given applied magnetic flux and the applied RF energy matches the neutrino-mediated transitions having energies with the highest $C\nu B$ flux. For an exemplary EPR RF frequency of 9.8203 GHz, the energy is 4.06×10^{-5} eV which is near the $C\nu B$ spectral flux peak in the region of 5×10^{-4} eV (Figure 3). Due to the $C\nu B$ spectral flux peak being higher in energy than the exemplary applied 4.06×10^{-5} eV RF radiation, the EPR spectrum may show the highest intensity with a negative slope at low field as shown in Figures 8A-B, 10, and 12-15. The cross

section for neutrino excitation-mediated EPR signal may further be significant in the energy range near a spin flip transition response having the applied magnetic flux corresponding to an energy nearly matching the energy of the applied RF frequency due to the higher transition probability of exciting low-energy fine structure transitions with corresponding low quantum numbers. Due to the multiplicity of possible transitions due to neutrino-molecular hydrinos dimer interactions and the $|\Delta m| \neq 1$ selection rules for neutrino excited spin-orbital coupling transitions, the EPR signal may be observed with the magnetic field and the RF field in a parallel as well as perpendicular orientation and further at zero magnetic field as discussed in the Dual-mode EPR section, *infra*. This aspect of the interaction permits an elucidation of a neutrino interaction effect and is strategic for neutrino communications. The selection rules for neutrino transitions may give rise to corresponding excited states with extended lifetimes giving rise to an inventory of molecular hydrino radicals with corresponding populated states that accumulate over time and populate or depopulate during spin flip transitions. In addition to the EPR signal intensity dependency on the profile of the $C\nu B$ energy spectrum, this mechanism may also explain the high, and potentially the highest, intensity at zero field with a profile having negative slope and may further predict the unique phenomenon of temporal changes to the zero-field intensity.

Temporal changes of EPR spectra due to accumulated changes in fine structure state populations and consequential EPR shifts assigned to excitation by $C\nu B$ neutrinos were observed on three samples of solidified tin that were processed into small flakes and inserted into a quartz EPR tube. Prior to collection, the tin served as a molten metal of electrodes in a hydrino reactor called a SunCell. This reactor described in Mills PCT Application [45] comprised two molten tin injectors wherein corresponding injected molten metal streams intersect to complete an electrical circuit to maintain a low voltage, high current through the molten metal streams in the presence of a source of atomic hydrogen and a source of HOH catalyst. A powerful plasma forming reaction was propagated according to Eqs. (1-4) with $H_2(1/4)$ as the product. A flat baseline of near zero slope was observed for 99.9% pure starting tin metal as shown in Figure 13 wherein the small signals were determined to be from the cavity background. The initial scan of the three tin samples collected from different SunCells post run are shown in Figure 16.

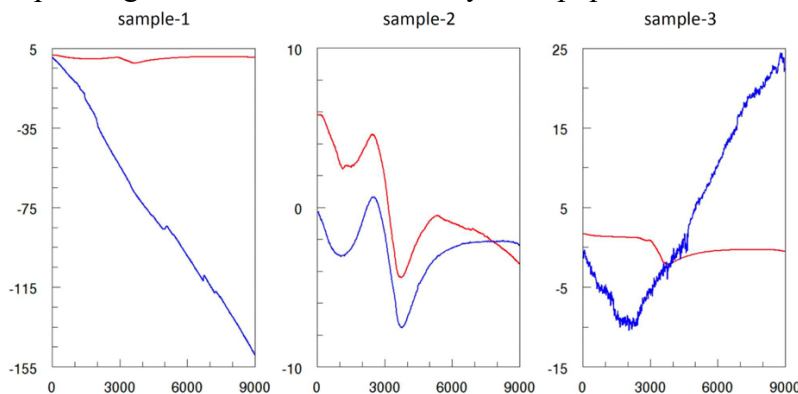
Figure 16. The 0-9000 G EPR spectra recorded at 9790 MHz on tin samples 1, 2, and 3 collected from different SunCells and processed into flakes. The sample numbers are indicated on the right. A high zero field intensity was observed. The black line indicates $g = 2$. The peak at 3000 G ($g = 2.2$) matches the -501 G downfield shifted peak of the $[H_2(1/4)]_2$ dimer.



The results of back-to-back EPR scans on sample 1 is shown by the top double traces. Variations in spectrum amplitudes were attributed to at least one of variations in tube filling factor and flake sample packing ordination in the EPR spectrometer magnetic field. The spectra comprised a main line at circa $g = 2.2$, a small shoulder at lower field, and a high-intensity broad resonance starting in zero field. The peak at 3000 G ($g = 2.2$) matches the -501 G downfield shifted peak of the $[H_2(1/4)]_2$ dimer.

The processing of the bulk tin samples into flakes was intended to increase the surface area of surface-coated molecular hydrino, unscreened by a coverage of molecular hydrino in the bulk state and present a surface binding state that interacts with $C\nu B$ neutrinos. The interaction over time was expected to give rise to an accumulation of a neutrino excited state population of molecular hydrino species. The results of repeating the EPR spectra shown in Figure 16 after eight days of storage at room temperature is shown in Figure 17. The spectra of samples 1 and 3 had changed to a negative sloping profile with the intensity of sample 1 being relatively strong. The negative slope for a maximum signal intensity at zero field indicates a shift of the signal intensity to a peak outside of zero field.

Figure 17. The 0-9000 G EPR spectra recorded at 9790 MHz on tin samples 1, 2, and 3 collected from different SunCells and processed into flakes initially after preparation as shown in Figure 16 (red traces) and following eight days of storage at room temperature (blue traces) indicating a shift of the signal intensity to a peak outside of zero field attributed to neutrino excitation to accumulate a corresponding excited state molecular hydrino population.



The peak of the blackbody curve of $C\nu B$ neutrinos is predicted to be at an energy of 2.35×10^{-4} eV covering the μeV - meV range with significant intensity at 1 meV. As a comparison, the energy of an applied RF power of 9.8 GHz is 1.05×10^{-5} eV. Consider an EPR applied flux over the region of 0 G to 9000 G. The resonance applied flux for $g = 2.0046386$ is 3498 G. The absorption of neutrino flux by molecular hydrino species creates an internal or intrinsic B flux that superimposes positively or negatively to the applied B flux corresponding to a parallel or antiparallel relative alignment to result in a Bohr magneton magnetic spin-flip transition when the total flux creates a resonance absorption of the applied EPR RF radiation to generate the EPR spectrum. Converting the B flux to an equivalent of a swept RF energy for the range of 0 to 9000 G field relative to the 9.8 GHz RF energy of 1.05×10^{-5} eV gives an EPR active molecular hydrino species with an intrinsic energy state of 1.05×10^{-5} eV (1.05×10^{-5} eV – 0 eV) at 0 G, 0 eV at 3498 G, and to -9.39×10^{-5} eV (1.05×10^{-5} eV - 1.044×10^{-4} eV) at 9000 G wherein positive and negative energy correspond to the intrinsic B flux aligned parallel and antiparallel to the applied field, respectively. Note that energy range of the EPR scan is well within the energy spectrum of the $C\nu B$ (Figure 3).

Over time, the molecular hydrino states of increasing energy may be populated such that the signal intensity is outside of the range of the scanned B flux (e.g. zero field and 9000 G). As shown in Figure 17, the 1st derivative of the 0 G to 9000 G EPR signal at a RF resonance energy of 1.05×10^{-5} eV starts at a point of maximum intensity at 0 G and ends at a point of minimum intensity at 9000 G indicating that the net parallel aligned population of excited state molecular hydrino species decreases over the scanned energy region from a high maximum population at an intrinsic energy of 1.05×10^{-5} eV (0 G) to 0 eV (3489 G). Thereafter only the antiparallel

aligned population of excited state molecular hydrino species can provide a resonance with the applied RF energy. The antiparallel aligned population of excited state molecular hydrino species also decreases towards the end of the Gauss range, over the intrinsic energy region of 0 eV at 3489 G to -9.39×10^{-5} eV at 9000 G. Consider the near constant negative slope of the EPR spectrum observed in Figure 17 given by $I = -CX$ wherein X is the applied B flux in Gauss, I is the 1st derivative of the EPR signal intensity, and $-C$ is the negative EPR spectral slope observed over the scanned region, 0 G to 9000 G. The slope is proportional to the acceleration of the population change with B flux. The corresponding integral of the EPR signal gives a population function consistent with observation of $I_p = I_0 - \frac{C}{2}X^2$ wherein I_p is proportional to the neutrino excited state population, I_0 is proportional to the maximum population at 1.05×10^{-5} eV (0 G), and the molecular hydrino intrinsic B flux is parallel to the applied B flux for $X < 3489$ G and antiparallel for $3489 < X$. The peak population is beyond the zero field (intrinsic 1.05×10^{-5} eV) and decreases over the entire range 0 G to 9000 G with a constant acceleration of the decrease rate. The peak population having an intrinsic energy state higher than that at zero field is consistent with the energy profile of the $C\nu B$ (Figure 3) that has a maximum intensity at greater energy than the 1.05×10^{-5} eV intrinsic molecular hydrino energy at 0 G.

The EPR spectral profile of sample 3 follows a neutrino excited state population given by the function $I_p = I_0 - \frac{C_1}{2}X^2$ for the region 0 G to 2000 G and $I_p = I_{0,2000G} + \frac{C_2}{2}X^2$ for the region 2000 G to 9000 G. The molecular hydrino intrinsic B flux is parallel to the applied B flux for $X < 3489$ G and antiparallel for $3489 < X$. C_1 is proportional to the acceleration in the decrease in excited state population in the region 0 G to 2000 G. In the region 2000 G to 9000 G, $I_{0,2000G}$ is proportional to the excited molecular hydrino population and C_2 is proportional to the acceleration in the increase in the excited state population. The population is a local maximum beyond the zero field (intrinsic 1.05×10^{-5} eV) and decreases over the entire range 0 G to 2000 G at a constant acceleration rate proportional to C_1 . Thereafter, the population increases at a constant acceleration rate proportional to C_2 with another local maximum at higher Gauss and corresponding intrinsic energy than 9000 G and 9.39×10^{-5} eV, respectively. For sample 3, neutrino absorption mediated accumulation of a high energy state population favors intrinsic antiparallel fine structure and related molecular hydrino states with the peak population beyond 9000 G under the sample characteristics and processing history. Alternatively, the transition of the neutrino absorption mediated state population peak to the zero field and high field limits of the B flux range may indicate that the high energy state inventory is being populated and accumulated by action of the EPR scanning. Specifically, the observed higher maximum signal at 9000 G relative to maximum at 0 G with a negative slope for $X < 3000$ G

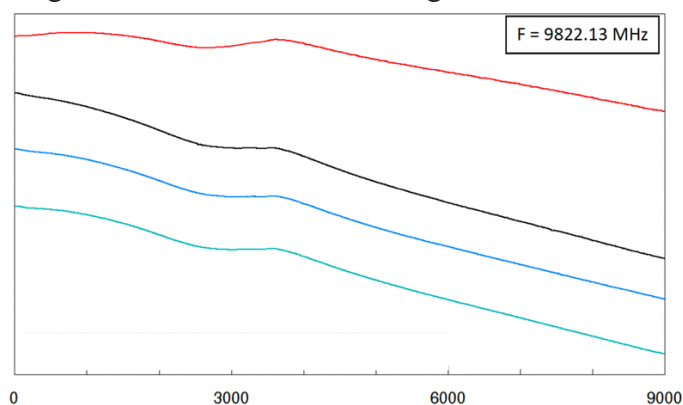
and positive slope for $X > 3000\text{G}$ may be due to the shape of the energy-population profile of the EPR active population relative to the scanned field position as the field and corresponding state intrinsic energy is scanned from 0 G to 9000 G. Here the high-energy inventory increases during scanning, and the energy-state populations switch between parallel and antiparallel alignment with the applied B flux to be resonant with the applied RF radiation as the field is scanned. In contrast to samples 1 and 3, sample 2 showed the typical $[\text{H}_2(1/4)]_2$ dimer peak at 3000 G and additionally a maximum intensity at zero field.

Samples 1, 2, and 3 were stored an additional 30 days at room temperature, and the EPR spectra were rerecorded for a second time. The spectral profile of sample 1 was essentially unchanged from the spectrum shown in Figure 17. The 2nd rerecorded EPR spectral profile of sample 3 converted to one with an acceleration of the population decrease over the range 0 G to 9000 G from a maximum at 0 G, matching the 1st and 2nd rerecorded profiles of sample 1. The 2nd rerecorded profile of the EPR spectrum of sample 2 was about equivalent to that of its 1st recorded spectrum (Figure 17). However, after running several spectra on sample 2, the EPR spectral profile also converted to one with an acceleration of the population decrease over the range 0 G to 9000 G from a maximum at 0 G as shown in Figure 18 (1st scan of stack). The converted sample 2 spectrum thereafter matched the 2nd rerecorded profiles of samples 1 and 3. This result indicates that causing electron spin-flip transitions by applying at least one of a magnetic field such as a scanned magnetic field and RF power such as a spin-flip transition resonant RF power may increase the rate of the populating neutrino excited states wherein spin-flip transitions may couple with neutrino excitation of fine structure transitions. Over time, the neutrino state excitation may favor a population having higher energy states beyond zero field which matches the energy-intensity profile of the $C\nu B$. After maintaining sample 2 in the EPR spectrometer at 4500 G for 30 minutes, the spectrum was recorded again. As shown in Figure 18 (2nd scan of stack) the population decrease over the range 0 G to 9000 G was at a higher accelerated rate relative to that of scan 1 as indicted by the negative EPR spectral slope which increased in magnitude relative to that of scan 1. Thereafter, the spectral profile was reproducible as shown by a following forward scan 3 from 0 G to 9000 G and a reversed-field direction scan 4 from 9000 G to 0 G.

Considering more details of Figure 18, all the scans show that the acceleration of the population decrease comprises three stages: (i) a near constant acceleration of the decrease in excited state population in the region 0 G to 3000 G at a 1st rate from a maximum population beyond zero field, (ii) a zero slope EPR spectral region between 3000 G and 3500 G corresponding to the resonance of $[\text{H}_2(1/4)]_2$ at 3000 G and the 0 eV energy state of neutrino excited state molecular hydrino species at 3500 G wherein the signal intensity may be maintained by the pure spin-flip transition resonance, and (iii) a constant acceleration of the

decrease in excited state population in the region 3500 G to 9000 G at a 2nd greater rate than that of the region between 0 G and 3000 G. The ability to change the EPR spectral dependence on the absorption of neutrinos by the application of at least one of controlled magnetic field and RF power can be exploited to at least one of transmit and receive telecommunication signals encoded in $C\nu B$ intensity variations controlled by manipulation of these parameters in at least one of strength, direction, intensity, power, frequency, and in time.

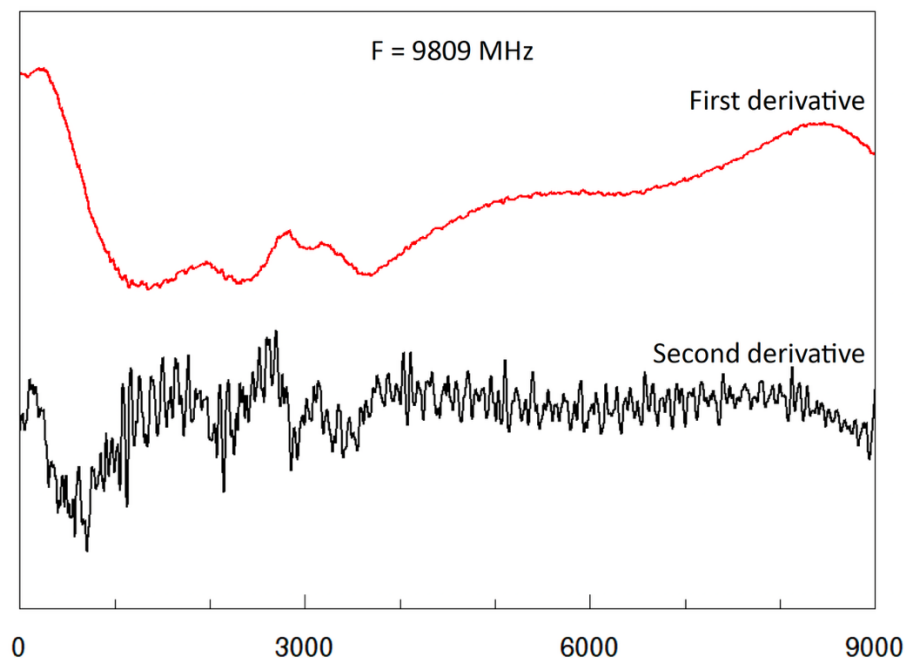
Figure 18. The 2nd rerecording of 0-9000 G EPR spectra of sample 2 (SunCell tin flakes) at 9822.13 MHz following room temperature storage for an additional 30 days beyond the recording of the spectra of Figure 17 wherein each scan required 4.5 minutes to acquire. Red trace. 1st scan after running several spectra which caused the spectral profile to change from a normal spectrum shown in Figure 16 to one with an acceleration of a decrease in population from a peak beyond zero field. Black trace. 2nd scan recorded after maintaining sample 2 in the EPR spectrometer at 4500 G for 30 minutes wherein the acceleration of a decrease in population increased in relative magnitude. Blue trace. 3rd scan immediately following the 2nd scan. Cyan trace. 4th scan recorded immediately following the 3rd scan except that the EPR magnetic field was reversed over the range from 9000 G to 0 G starting at 9000 G.



The SunCell was loaded with 99.9% pure tin (RotoMetals) and plasma was maintained with a closed-system Ar/H₂(5%) atm for two minutes, and a sample was collected from the molten metal inside of the SunCell quartz chamber. Dimer magnetic dipole and fine structure transitions of energies given by Mills Chp. 16 [1] and in Hagen Mills [38,39] where determined to span the entire 0 to 9000 G region by taking the second derivative EPR spectrum (Figure 19). The near flat variation in second derivative intensities indicates a near uniform population of spin-orbital coupling states and subsequent transitions and reflects the nearly flat $C\nu B$ intensity profile (Figure 3) over this energy region. Assignment to noise was ruled out due to the reproducibility of the second derivative peaks and the absence of the lines in tin control (Figure 13) and other control spectra. Moreover, when comparing a series of peaks that were

reproducible within each sample, inter-sample variation was observed as expected based on the observed temporal dependency of the spectra and the non-identical nature of the samples such as the molecular hydrino dimer inventory, the surface conditions of the samples, and the population of fine structure levels and corresponding transitions dependent on neutrino interactions. Figure 19 shows the resolution of the individual transitions fine structure transitions that are assigned to the source of the broad features over large spectral ranges (e.g. 0-9000 G).

Figure 19. The 0-9000 G EPR first derivative (red) and second derivative (black) spectra recorded at 9809 MHz on a tin collected from a closed SunCell run for two minutes and processed into flakes indicating a superposition of many dimer magnetic dipole and fine structure transitions that span the entire 0 to 9000 G region with a maximum signal at zero field attributed to neutrino excitation to accumulate a corresponding excited state molecular hydrino population.

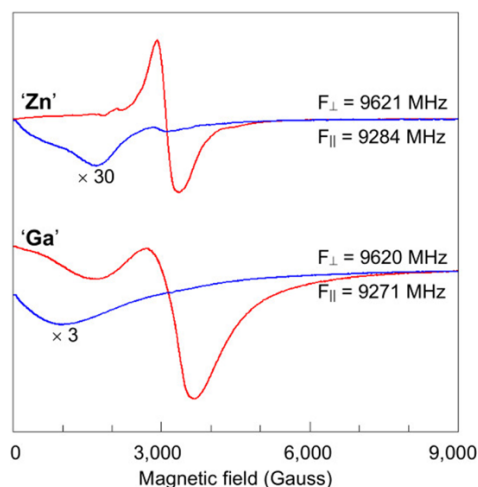


Dual-mode EPR

As discussed in the Temporal changes in the zero field EPR of tin-hydrino samples section the cross-section and corresponding intensity may be significant at zero field, and the intensity at zero field may change over time due to neutrino-hydrino interactions which may be strategic for telecommunication signals. Specifically, due to the multiplicity of possible transitions due to neutrino-molecular hydrinos dimer interactions and the $|\Delta m| \neq 1$ selection rules for neutrino excited spin-orbital coupling transitions, the EPR signal may be observed with the magnetic field and the RF field in a parallel orientation and further at zero magnetic field to

permit an elucidation of a neutrino interaction effect. At sufficiently low magnetic field B_0 the high-field selection rule $|\Delta m_S| = 1$ for allowed EPR transitions will no longer be strictly valid due to level mixing by the zero-field interaction. In high-field notation, the selection rule softens to $|\Delta m_S| = 1, 2, \text{etc.}$, and EPR intensity may now also be detected in parallel mode, that is, for the magnetic component of the microwave $B_1 \parallel B_0$ [38-39]. In a prior reported study [38], two samples from the two different methods (plasma explosion versus ball milling) with relatively strong regular-mode ($B_1 \perp B_0$) EPR amplitude were selected to check for intensity in parallel mode (Figure 20). The parallel spectrum is a method to isolate or control the neutrino interaction component of the EPR spectrum. The component is about 1/3 of the total EPR signal at zero field and decreases slowly as it approaches the resonance field for the constant 9.8 GHz applied microwave power indicative of a strong neutrino interaction dependence of the EPR signal in the zero-field region.

Figure 20. Perpendicular-mode (red traces) and parallel-mode EPR of molecular hydrino in two different samples. ‘Zn’ is $\text{Zn(OH)}_2\text{@H}_2(1/4)$ or molecular hydrino produced in a Zn wire detonation of an H_2O atmosphere. ‘Ga’ is molecular hydrino produced in a ball-mill experiment in which the starting material was $\text{NaHCO}_3/\text{NaCl}/\text{Ga}$ as 47.5/47.5/5 wt%, which was treated in a Retsch stainless steel mill for 6 hours at 300 rpm. Experimental EPR conditions: perpendicular- and parallel-mode frequencies as indicated; modulation amplitude, 10 Gauss; microwave power, 32 mW; temperature, 293 K. The amplitude of the parallel-mode spectrum has been multiplied by a factor 30 (‘Zn’) or 3 (‘Ga’) compared to the perpendicular-mode spectrum.



As in previous spectra (e.g. Figures 8A-B, 10, and 12-15) both samples have perpendicular-mode spectral features at low field extending into zero field. In parallel mode the central $|\Delta m| = 1$ line around $g \approx 2.1\text{--}2.2$ is strongly suppressed, making the low-field features stand out

indicating that they arise from $|\Delta m| \neq 1$ transitions. The peak shapes are different from their equivalents in perpendicular mode. Also, they start off from zero field at or below the baseline and with a negative slope, suggesting that (more than) half of these features have disappeared into zero field. These observations are consistent with the assignment of the parallel mode transitions to neutrino- $H_2(1/4)$ dimer spin-orbital coupling and other enabled transitions wherein the selection rules allow $|\Delta m| \neq 1$ transitions.

$H_2(1/4)$ - H_2 Dimer

The experimental confirmed theoretical downfield field shifts due to the end-to-end magnetic dipole interaction between van der Waals bonded $H_2(1/4)$ and $H_2(1/8)$ monomers are 502 G and 4028 G [38], respectively. Using multi-frequency EPR, the dimer shift was shown to be independent of the EPR frequency demonstrating that the mechanism was due to the predicted dimer member magnetic dipole-dipole interaction [1,38]. Furthermore, consider the dimer that H_2 forms with $H_2(1/4)$ due to van der Waals forces. Using Eqs. Mills GUT (16.206) and (16.207) [1] with a normalized linear combination of the H_2 and $H_2(1/4)$ central fields and the dipole moments of $(4+1)e/2 = 2.5e$ and 0.1334 D, the calculated $[H_2(1/4)-H_2]$ dimer bond length $2c'$ and bond energy given by Eqs. (16.210) and (16.213) are $3.04707a_0$ and 0.03309 eV (384 K). $H_2(1/4)$ - H_2 gas as well as very large quantities of hydrogen gas are observed by gas chromatography of gas released from sources and samples of $H_2(1/4)$ wherein a mixture of H_2 , $H_2(1/4)$, $H_2(1/4)$ - H_2 and low amounts of $[H_2(1/4)]_2$ are present [32]. This is consistent with the high bond dissociation temperature. Sources of H_2 are from decomposition of $H_2(1/4)$ - H_2 and condensation of H_2 in violation of the Clausius Clapeyron equation due to the raising of the H_2 liquefaction temperature by co-condensation with $H_2(1/4)$ [32]. Remarkably, compounds such as $Zn(OH)_2$, ZnO , $Ga(O)OH$, and Ga_2O_3 that do not ordinarily store hydrogen gas do in the presence of $H_2(1/4)$ [32] indicative of a new very significant technology comprising the conversion of common salts to hydrogen storage materials which are of significant industrial value.

A molecule with an unpaired electron (a radical) can interact with a second molecule to induce or alter the orbital angular momentum during a reaction to form a bond between the two molecules or by through-bond intramolecular angular momentum transfer, primarily through a phenomenon called spin-orbit coupling wherein the total angular momentum of the two reacting or interacting molecules must be conserved. Consider the formation of the van der Waals bond between $H_2(1/4)$ and H_2 . Bond formation results in the rearrangement of charge density of the molecular hydrido and molecular hydrogen. The corresponding electric potential energy of the mutually induced electric dipole formed in the corresponding MOs of the reactants is the equivalent energy of a covalent bond formed between the two proximal protons of the linear

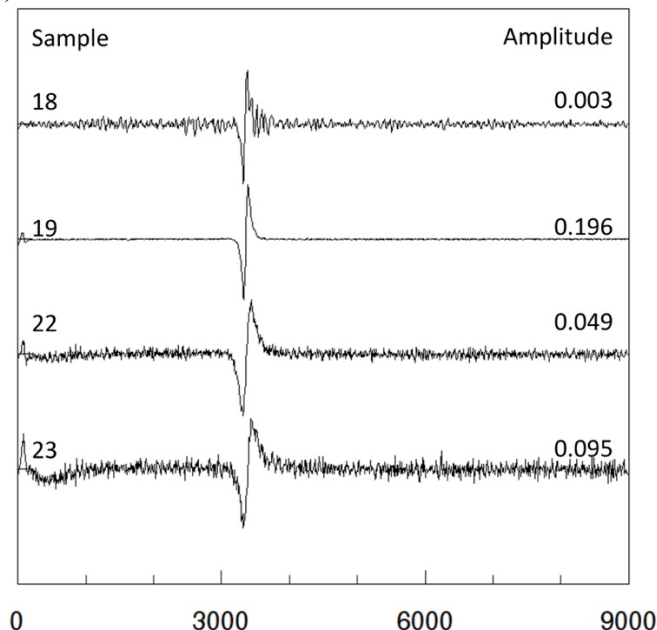
dimer oriented along the internuclear axes of the two molecules at the internuclear distance that establishes the equivalence of the Coulombic and covalent bond energies. Due to the much stronger competing covalent bonds of $H_2(1/4)$ and H_2 , the electrons of the reacting MOs form the van der Waals bond involving the rearrangement of the charge densities of both molecules to create the Coulomb potential energy between the bonding molecules.

The resulting dimer can be lowered in energy by the formation of a magnetic moment in H_2 to interact with the Bohr magneton, μ_B , of magnetic moment of the unpaired electron of $H_2(1/4)$. This state can be formed while conserving angular momentum by an allowed transition of $H_2(1/4)$ absorbing one or more neutrino spin $\frac{1}{2}$ photons to excite one or more of its spin-orbital coupling energy levels and then transferring the angular momentum through the van der Waals dimer bond to H_2 . The intramolecular angular momentum transfer is favored due to the relatively high energy of the spin-orbital transitions in hydrino molecules. Also, the H_2 selection rules for photon excitation or decay are typically those of electric dipole transitions involving spin 1 photons with $\hbar$ of angular momentum. Consequently, the orbital angular momentum state induced in H_2 by angular momentum transfer may have a relatively long lifetime.

Due to the conserved spin $\frac{1}{2}$ angular momentum of the neutrino, H_2 acquires $\frac{\hbar}{2}$ and $\hbar$ of angular momentum with the angular momentum transfer corresponding to one neutrino and two neutrinos absorbed by $H_2(1/4)$ during spin orbital coupling. The corresponding magnetic moments are $0.5\mu_B$ and μ_B , respectively. The magnetic flux due to the magnetic moment of H_2 interacting $H_2(1/4)$ of the $H_2(1/4)$ - H_2 dimer reduces the external magnetic flux that needs be applied to achieve resonance with a fixed RF frequency during EPR spectroscopy and thereby causes a downfield shift in the EPR spectrum. $H_2(1/4)$ - H_2 dimer may further absorb at least one neutrino photon to excite spin-orbital coupling states and corresponding energies of $H_2(1/4)$ to cause a further corresponding downfield EPR shift.

The hydrogen molecule of the $H_2(1/4)$ - H_2 dimer may comprise an H_2 orbital magnetic moment in addition to the spin magnetic moment of the $H_2(1/4)$ molecule wherein the H_2 magnetic moment may be formed by neutrino-interaction mediated angular momentum transfer from a neutrino excited spin-orbital state of $H_2(1/4)$ to H_2 by through the van der Waals bond. As in the case of $[H_2(1/p)]_2$ such as $p = 4$ and $p = 8$, the magnetic moments may interact along the internuclear axis of the dimer to cause a downfield EPR resonance. Taking the third derivative of the EPR signal eliminates broad peaks that can obscure relatively narrow linewidth peaks. The third-derivative EPR spectra of samples of Table 1 each having a downfield shifted peak in the first derivative EPR spectrum shown in Figure 15 were processed, and spectra having a new peak elucidated by the third-derivative processing are shown in Figure 21.

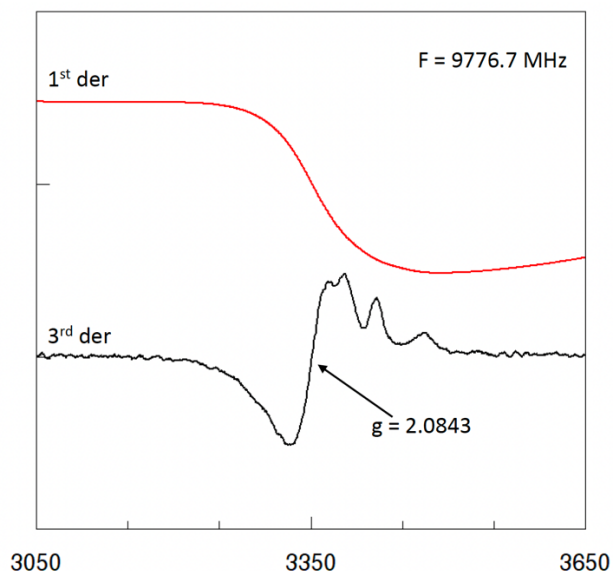
Figure 21. The 0-9000 G EPR third derivative spectra of samples 18, 19, 22, and 23 of Table 1 recorded at 9778 MHz. The sample numbers are indicated on the left, and the relative amplitudes of the EPR signals are indicated on the right. The peak observed at $g = 2.08 \pm 0.01$ was assigned to $H_2(1/4)-H_2$.



The magnetic dipole-dipole interaction energy for the two molecules of the dimer $H_2(1/4)-H_2$ aligned along the internuclear axes is given by Mills Eq. (16.252) wherein the magnitude of the induced H_2 orbital magnetic moment may have a magnitude of $0.5\mu_B$ or μ_B . The spin-orbital coupling energy for $H_2(1/4)-H_2$ is given by Mills Eq. (16.241). Neutrino- $H_2(1/4)-H_2$ interaction such as absorption of a neutrino photon may occur to excite an $H_2(1/4)$ spin-orbital coupling energy level to shift the spin flip transition energy. The allowed spin flip transitions with spin-orbital coupling of $H_2(1/4)$ of the linear $H_2(1/4)-H_2$ dimer comprising the orbital angular momentum and magnetic moment coupled H_2 correspond to spin-orbital coupling quantum numbers $m = 0$ and $m = 2$. The corresponding predicted down-field EPR shifts are -123 G and -131.6 G, respectively. The EPR spectrum of sample 19 recorded for 4 hours at 9776.7 MHz and averaged is shown in Figure 22. The peak of $H_2(1/4)$ was predicted to be at 3485 G where an asymmetric peak is observed with zero crossing at about this position considering that the baseline is elevated in this region. The peak due to $H_2(1/4)-H_2$ dimer with H_2 orbital magnetic moment $0.5\mu_B$ was predicted at 3423 G. The baseline is also elevated in this region which shifts the signal intensity downfield, but considering a baseline correction there is a large feature with a possible zero crossing at 3428 G. The $H_2(1/4)-H_2$ peak with H_2 orbital magnetic moment μ_B and spin-orbital coupling quantum number 2 was predicted at 3353.6 G

corresponding to a g factor of 2.083. The peak was observed at 3351.4 G corresponding to a g factor of 2.0843. The $\text{H}_2(1/4)\text{-H}_2$ dimer with H_2 orbital magnetic moment μ_B and spin-orbital coupling quantum number 0 was predicted at 3362 G. A small shoulder peak on the 3351.4 peak was observed at 3369 G which is assigned to this transition wherein the zero crossing may be distorted by the much larger downfield peak at 3351.4 G.

Figure 22. The first and third derivative 0-9000 G EPR spectra of sample 19 of Table 1 recorded at 9776.7 MHz for 4 hours and averaged. The peak observed at $g = 2.0843$ was assigned to $\text{H}_2(1/4)\text{-H}_2 \mu_B - \mu_B$ magnetic dipole-dipole interaction with allowed spin-orbital coupling quantum number 2. The shoulder at 3369 G was assigned to $\text{H}_2(1/4)\text{-H}_2 \mu_B - \mu_B$ magnetic dipole-dipole interaction with spin-orbital coupling quantum number 0. The peak at 3428 G was assigned to $\text{H}_2(1/4)\text{-H}_2 \mu_B - 0.5\mu_B$ magnetic dipole-dipole interaction. The peak at 3485 G was assigned to $\text{H}_2(1/4)$.



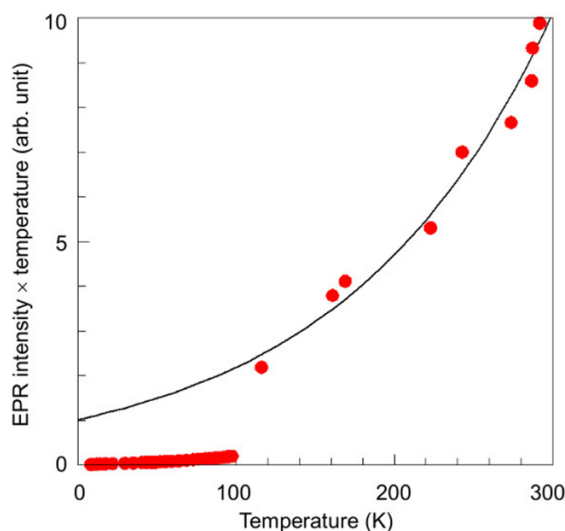
EPR temperature dependence and its implications for signal transmission

Temperature may be used to switch an EPR signal on, and off which has utility for signal transmission. For example, at low temperatures, it was observed that $[\text{H}_2(1/4)]_2$ dimers side to side anti-paired to form tetramers that were not EPR active. As the temperature was raised the EPR singlet for the dimer reappeared at the predicted temperature. The EPR spectrum on a sample comprising a molecular hydrino dimer (e.g. $[\text{H}_2(1/p)]_2$ or $\text{H}_2(1/p)\text{-H}_2$) may be varied by controlling the temperature of the sample which reversibly varies at least one of the intra-dimer and inter-dimer bonding wherein an EPR peak that requires at least partial excitation or de-excitation involving neutrinos (e.g. neutrino flux of the cosmic neutrino background ($C\nu B$)) is eliminated or formed when a bond is broken. EPR transition may involve a neutrino fine structure excitation directly or may involve a downfield shift created by fine structure to orbital angular momentum transfer in a partner of a multimer such as one comprising $\text{H}_2(1/p)\text{-H}_2$ or $[\text{H}_2(1/p)]_2$ resulting in a magnetic dipole-dipole interaction. The bond may comprise an intra-dimer van der Waals bond between two $\text{H}_2(1/p)$ molecules of the $[\text{H}_2(1/p)]_2$ dimer that gives rise to a magnetic dipole-dipole interaction and a corresponding down-field shifted EPR peak that is broadened by neutrino fine structure transitions. The bond may be weakened and ultimately broken with an increase in temperature to eliminate the corresponding EPR peak. Alternatively, the bond may comprise an inter-dimer bond comprising an antiparallel side-to-side magnetic dipole-dipole bonding between two linear dimers (e.g. $[\text{H}_2(1/p)]_2\text{-}[\text{H}_2(1/p)]_2$). The EPR spectrum may decrease in intensity and ultimately be eliminated at a dimer pairing temperature as the strength of the bonding increases with decreasing temperature. During bonding to form the tetramer, neutrino fine structure transitions may be enhanced relative to the intra-dimer magnetic dipole-dipole interaction which is dependent on the inter-dimer bonding which cancels the magnetic dipole-dipole interaction and spin flip transition.

The elimination of an EPR peak by elevating the temperature is limited to less than room temperature, ~ 300 K, which is a challenge to EPR detection of the EPR signal loss as the temperature is increased given that the predicted van der Waals bond dissociation temperatures for $\text{H}_2(1/4)\text{-H}_2$, $[\text{H}_2(1/4)]_2$, and $[\text{H}_2(1/8)]_2$ are 384K, 512K, and 4206K, respectively. In contrast, EPR is well suited for performing EPR spectra at cryogenic temperatures. Mills Eq. (16.254) [1] predicts that two $[\text{H}_2(1/p)]_2$ dimers form tetramers $[\text{H}_2(1/p)]_2\text{-}[\text{H}_2(1/p)]_2$ by magnetic dipole bonding alongside the semiminor axis (side-to-side) versus bonding along the semimajor axis (end-to-end) by van der Waals induced electric dipole bonding. At 95 K, the bond energy of 8.197×10^{-3} eV far exceeds the EPR transition energy of about 4.05×10^{-5} eV at 9.8 GHz excitation such that the dipole paired dimer has no EPR signal. The 95K transition for EPR active to inactive may be broadened to higher temperature by the confinement and effective pressure caused by the state of $[\text{H}_2(1/4)]_2$ being entrapped as inclusions in the host crystalline

lattice. A dramatic decrease in the EPR signal intensity is observed (Figure 23) at about this temperature which decreases to about 1/7.5 the intensity observed above this temperature, with a further slow continuous decrease to a measured temperature of 8K. This intensity-temperature relationship is anticipated considering the statistical thermodynamics of a mixture of monomer, dimer, side-to-side paired multimers and other species that increase the entropy of the system (i.e., absence of signal would require perfect side-to-side pairing of all $\text{H}_2(1/4)$ which is a very unfavorable and improbable state for an entrapped inhomogeneous mixture.). Conversely an exponentially increasing population of free $[\text{H}_2(1/4)]$ species is anticipated as function of increasing temperature according to Maxwell–Boltzmann statistics (Chapter 24 in [1]) which applies to a free gas-like state obtained at higher temperatures.

Figure 23. Relative population of the $\text{Zn}(\text{OH})_2 @ \text{H}_2(1/4)$ paramagnet measured as EPR intensity times temperature versus temperature. For an $S = 1/2$ system or an isolated ground state this graph should be a straight horizontal line. EPR intensity was measured as height times width of the central line. A small transition range around 107 K is ignored. The black line is a single-exponential fit to the $T \geq 116$ K data. The figure indicates that even at room temperature the spin system has not reached its maximal population by far.

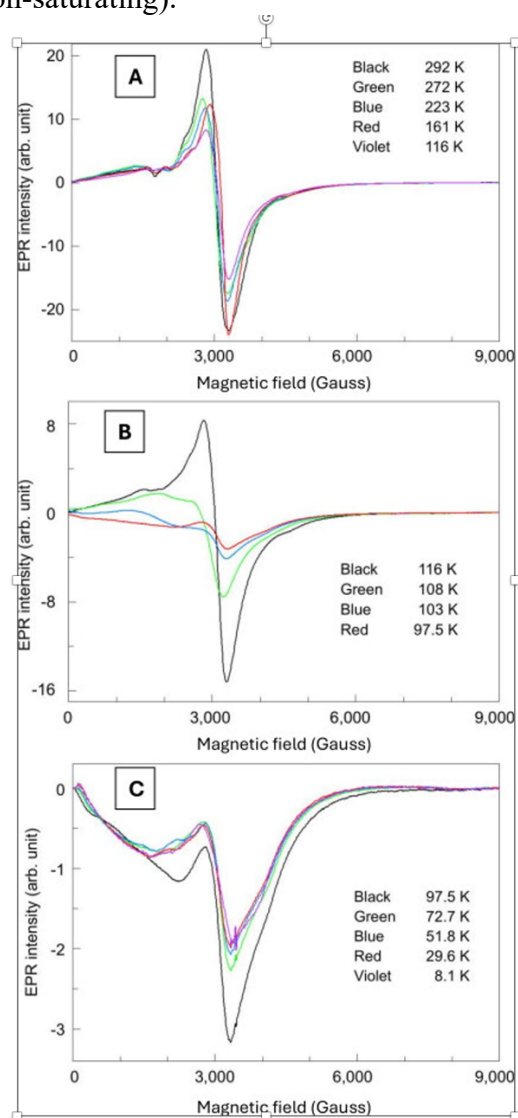


The sample temperature may be changed to selectively enhance the intensity of an EPR signal involving the absorption of neutrinos with the excitation of the corresponding fine structure and other transitions of $\text{H}_2(1/p)$ or dimers or multimers comprising $\text{H}_2(1/p)$ during a EPR spin-flip transition. For example, the side-by-side antiparallel bonding of two $[\text{H}_2(1/p)]_2$ dimers eliminates the spin flip transition having allowed quantum numbers $m = \pm 1$. As the temperature approaches the limit that causes extinction of the spin flip transition, the corresponding EPR signal decreases while the neutrino dependent transitions having allowed

quantum numbers $m \neq \pm 1$ involving fine structure transitions are not affected, and thus the corresponding intensities relatively increase in the EPR spectrum.

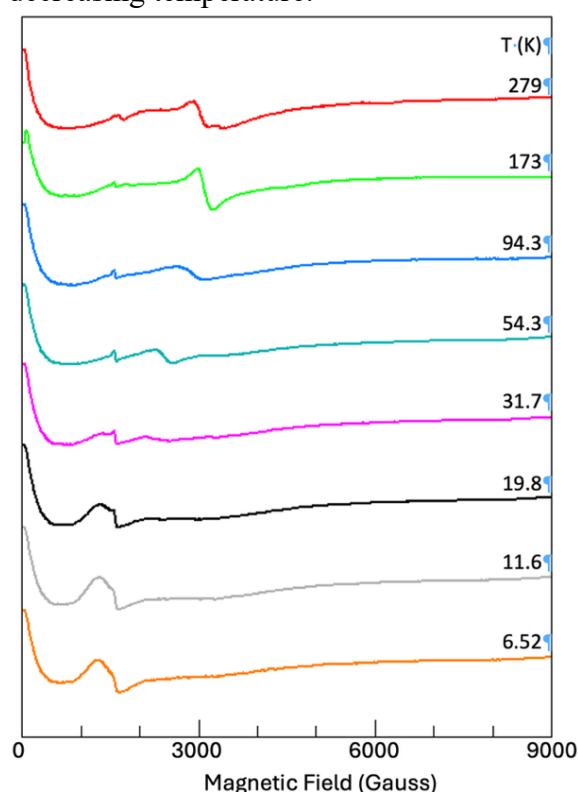
The $\text{Zn(OH)}_2@H_2(1/4)$ sample of Figures 6, 19, and 23 was studied in regular X-band as a function of sample temperature from 292 K down to 8 K as shown in Figures 24A-C. Figure 24, panel A, shows selected spectra for ‘high’ temperatures down to 116 K. Remarkably, the signal was not constant in shape: significant variations were observed in the shoulders of the main peak and also in the low-field region of $|\Delta m_s| > 1$ transitions. Even the main peak itself exhibited changes in position, or apparent g value, and in width. These variations were not related to saturation; the signals did not show any saturation at all up to maximal incident power of 0 dB = 200 mW. Perhaps even more notable is the unusual relation between intensity and temperature. The signal slightly decreased with decreasing temperature over this region, where a paramagnet in an isolated ground state would rather increase according to Curie’s law by a factor of 292/116. Overall, the powder pattern was qualitatively invariant until a small temperature range of some 10 K was reached around the value of $T \approx 107$ K, for which selected spectra are presented in panel B of Figure 24. In this narrow slot, drastic changes occurred eventually resulting in an order-of-magnitude change in the main-peak amplitude and in a powder pattern that is essentially completely below the zero baseline, indicating that a large part of the EPR absorption spectrum has moved into zero field demonstrating the selective enhancement of transitions involving neutrino interactions. From this temperature window downwards, the new overall signal was again qualitatively invariant in shape as well as in intensity, as shown in panel C of Figure 24. The black trace in panel C ($T = 97.5$) is identical to the red trace in panel B. It still showed some effects of the drastic changes that took place over the ca 10 K slot around $T \approx 107$ K. At lower temperatures, however, the amplitude became virtually independent of the temperature. The negative slope at zero field indicates the absorption of neutrinos and the accumulation of an inventory of molecular hydrino radicals with neutrino populated excited states that can give rise to spin flip transitions resonant with the applied RF without the application of B flux wherein the excitation may involve higher energy neutrino photons outside the range of zero field. Minor changes in the shoulders of the main peak and in the low-field range were also observed demonstrating the relative dependence of spin-flip transition and relative independence of the neutrino fine structure transitions on the cryogenic temperature. Down to 11 K no saturation whatsoever was observed for a power range of -40 to 0 dB (where 0 dB corresponds to 200 mW). Repeated cycling from room temperature down to 8 K resulted in fully reproducible spectra.

Figures 24A-C. Temperature dependence of the broad X-band EPR signal from $\text{Zn(OH)}_2@H_2(1/4)$ shows three different phases. Panel A, high-temperature phase in which the intensity of a relatively sharp central line only minorly decreases with decreasing temperature, accompanied by small changes in the width and position (effective g value) of the central peak, in shoulders, and in low-field features. Panel B, transition temperature range in which the spectral pattern drastically changes over a small temperature range of ca 10 K around ca 107 K to eventually turn into the ‘low-temperature’ spectrum with an order-of-magnitude decrease in amplitude associated with a transfer of large part of the EPR into zero field. Panel C, low-temperature phase in which the spectral intensity is essentially invariant with the temperature, however, again with a range of small changes in shoulders and low-field features. EPR conditions: microwave frequency 9405-9406 MHz; modulation amplitude, 10 Gauss; microwave power, -4 dB, that is 80 mW (non-saturating).



The sample $\text{KHCO}_3\text{-KCl}$ (50/50 wt%) demonstrates (Figure 25) a temperature dependent shift of a molecular hydrino spectrum absent the EPR signal extinguishing tetramer formation. However, the EPR signal shifts dramatically to lower field at cryogenic temperatures with increasing intensity at zero field indicative of the signal's dependence on neutrino absorption to cause excitation of fine structure with consequential neutrino dependent shifts and broadening. This effect further demonstrates the potential to use temperature shifts to control the transmission and reception telecommunication signals using the $C\nu B$ flux as the signal carrier.

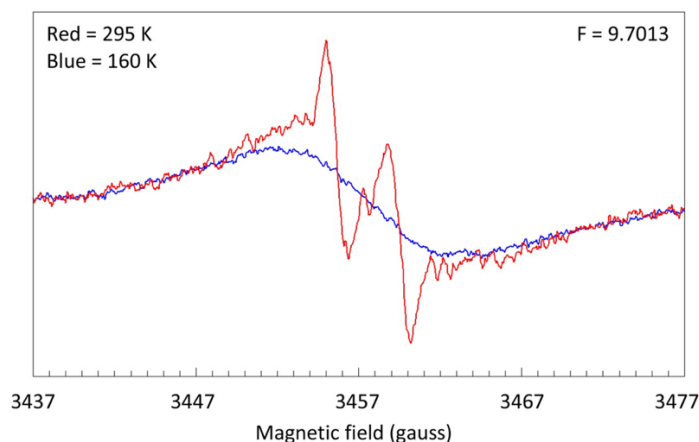
Figure 25. The EPR spectra of $\text{KHCO}_3\text{-KCl}$ (50/50 wt%) showing the dramatic shift of the signal to lower field with decreasing temperature.



The absorption of neutrinos can be further controlled by manipulating the EPR spectrum through interactions of $\text{H}_2(1/p)$ and $[\text{H}_2(1/p)]_2$ with the lattice in which it is embedded by mechanisms such as changing the morphology of the lattice crystalline structure or changing the sample temperature, which in turn changes the internal energy states of the lattice and possibly the lattice morphology. Hagen and Mills [39] showed that the hexagonal structure of $\text{Ga(O)OH@H}_2(1/4)$ showed the sharp series of peaks corresponding to spin flip transitions with fine structure transitions corresponding to spin orbital coupling and fluxon linkage (Figure 4a). The excitation of the fine structure transitions is likely due to neutrino absorption. In addition, a broad peak centered on the same g factor was observed under the spectrum comprising the

$H_2(1/4)$ fine structure. As shown in Figure 26, it was observed that lowering the temperature of the $Ga(O)OH@H_2(1/4)$ resulted in the complete elimination of the $H_2(1/4)$ fine structure peaks while the underlying broad peak was unaffected. Using X-ray diffraction, it was determined [39] that the $Ga(O)OH@H_2(1/4)$ lattice having an EPR spectrum with the fine structure comprised a hexagonal crystalline structure which existed at room temperature and converted to orthorhombic phase of $Ga(O)OH@H_2(1/4)$ at cryogenic temperature that produced the broad $H_2(1/4)$ peak. The data demonstrates the ability to manipulate the EPR spectrum by the structure and temperature of the lattice which can thereby be exploited to manipulate neutrino absorption such as that required to excite fine structure transitions of $H_2(1/4)$ at determined parameters (e. g. B flux in EPR).

Figure 26. EPR differential temperature dependence of the molecular hydrino signal with sharp fine structure features and a broad underlying signal wherein the amplitude of the 295 K spectrum was scaled to match that of the 160 K spectrum. Upon lowering the measuring temperature from ambient to 160 K the hydrino spectrum with well resolved fine structure completely disappeared by saturation. The underlying broad signal was not affected. The difference was determined to be due to a conversion of the crystalline morphology from hexagonal to orthorhombic, respectively.

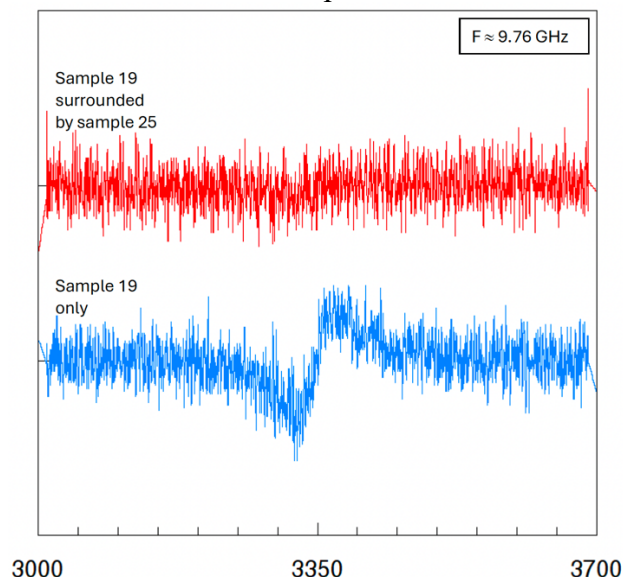


***CvB* Blocker Effect**

In addition to sample temperature control to control the EPR spectrum as a means of controlling a telecommunications signal received at a “receiver material”, at least one spin-flip EPR peak may be attenuated or eliminated by an intervening absorber or “blocker material” of the cosmological neutrino background (*CvB*) flux. Each of the “blocker material” and the “receiver material” are a composition of matter comprising molecular hydrino (e.g. $[H_2(1/p)]_2$ and $H_2(1/p)-H_2$) having a neutrino-excitation dependent (e.g. spin-orbital coupling and fluxon linkage transition) EPR signal at a selected B flux or flux range. Due to nature of the *CvB* flux to be constant and finite, the telecommunication signal transmitter may comprise the “blocker material” to encode the signal in neutrino flux intensity variations with time. The neutrino flux required to be incident on the “receiver material” to excite the neutrino-dependent selected EPR signal may be at least partially attenuated by at least partially encapsulating the “receiver material” with the “blocker material” such that the selected signal at the “receiver material” is attenuated or eliminated. The attenuator or “blocker material” may comprise a highly magnetic material comprising at least one of molecular hydrino and dimers that strongly interact with neutrino flux wherein the high magnetism of the encapsulating sample relative to the encapsulated sample whose EPR spectrum is recorded is due to a much higher concentration of molecular hydrino or dimer in the encapsulating sample.

A material comprising a high concentration of molecular hydrino may serve as a blocker of the *CvB* flux. Sample 25 was observed to be a strong neutrino absorber based on the intensity of its EPR spectrum and its near ferromagnetism indicative of a high molecular hydrino concentration. The blocking mechanism of the near total absorption of the *CvB* flux by a strong neutrino absorber sample that surrounds a receiver sample that requires neutrino interaction to observe a peak of interest was tested using test sample 19 surrounded by sample 25. Specifically, sample 19 (height 12 mm) was placed in a thin EPR tube (OD 2.6 mm) that in turn was placed in a larger diameter EPR tube (OD 4.6 mm) filled with sample 25 (height 40 mm). The results given in Figure 27 show that the EPR signal of sample 19 that required neutrino absorption to be allowed was eliminated when it was surrounded by sample 25 which could block the *CvB* flux by its absorption.

Figure 27. Third derivative EPR spectrum over the range 3000-3700 G showing that the neutrino-absorption-dependent spin flip transition of $H_2(1/4)-H_2$ of sample 19 present in this selected range was extinguished by surrounding it with another neutrino absorbing sample capable of eliminating the $C\nu B$ flux incident on sample 19.



Another means to demonstrate neutrino absorption comprises recording EPR spectra on at least two separated samples comprising molecular hydrino wherein at least one of the RF or magnetic field is at least one of frequency and amplitude modulated at one sample comprising an emitter. The modulation signal may be detected when the other sample comprising the receiver detects the transmitted modulation further comprising detected EPR intensity gaps at neutrino absorption energies. Magnetic field modulation is a standard method exploited in EPR spectrometry to increase signal to noise during signal detection. A continuous mode or one comprising the modulation may further involve a perturbative selective excitation of at least one transition of at least one of the nuclei (e.g. nuclear spin transition) of the hydrino molecule and a paramagnetic ion additive (e.g. electron spin transition such as that of Mn^{2+} shown in Figures 9A-B) to the material comprising at least one hydrino molecule wherein the perturbative selective excitation may be exploited to effects a neutrino mediated signal that encodes information. The effect may be mediated by influencing the neutrino interaction or absorption of at least one hydrino molecule.

Transmitter and receiver technologies

As an alternative to continuous wave EPR for telecommunication systems, pulsed EPR excites spin flip transitions across a selected frequency band simultaneously, with the application

of a high energy microwave pulse at a selected fixed applied magnetic field strength over a scannable range, records the free induction decay signal, and transforms the time domain signal into a frequency domain signal by Fourier transform processing. The rapid scan (RS) EPR may comprise small permanent magnets and miniaturized electronic components such as voltage-controlled oscillators (VCO) capable of sweeping the frequency at a fixed magnetic field that replace the bulky electromagnets and microwave parts that operate with a fixed microwave frequency and scan the magnetic field. The EPR spectrometer may be fully integrated into a single silicon microchip, a so called EPR-on-a-Chip (EPRoC). K nstner et al. [46] report on a microelectronic EPRoC device that operate at scan rates of up to 10^4 THz s⁻¹ via scan widths of more than 2.4 GHz (85.6 mT) and repetition rates of 2 MHz or more. The limited scan range corresponding to the high-power excitation pulse at a selected magnetic field may be advantageous to the selection of an energy region created by neutrino interaction with molecular hydrino wherein the total or integrated signal intensity over the selected region is representative to the neutrino flux. Moreover, the power consumption of pulsed EPR is low. Farsi et al. [47] report that the power consumption of their 0.7 mm² microdevices consumes less power than 100 mW. The sensitivity is very high due to the use of kilowatt microwave pulses versus ~10 mW continuous wave (CW) power used in CW EPR. For typical conventional high-performance X-band (ca. 9.5 GHz) pulsed EPR systems, the absolute sensitivity for a single echo acquisition is on the order of 10^9 to 10^{11} spins, translating to normalized sensitivities around 10^7 spins/ $\sqrt{\text{Hz}}$ in standard setups, down to fewer than 10^4 spins/ $\sqrt{\text{Hz}}$ in specialized or micro-resonator configurations, and cryogenic superconducting micro-resonators and parametric amplifiers enable single-shot limits down to hundreds of spins (260 total spins) or 65 spins/ $\sqrt{\text{Hz}}$ [48]. As a comparison continuous wave (CW) EPR requires absolute number of spins on the order of 10^{10} to 10^{13} total spins, and the sample typically contains 10^{13} to 10^{16} total spins.

As another alternative to microwave resonators (e.g. cavities or loop-gap resonators) to apply microwave pulses and measure the precessing electron spin magnetization, an EPR spectrometer may comprise a SQUID magnetometer as a sensitive magnetic resonance detector for pulsed scanning of the RF frequency at a fixed magnetic field [49]. Alternatively, the magnetic field or the frequency may be swept wherein quantitative measurements at high fields and high frequencies are achievable [50]. The SQUID may comprise a direct current superconducting quantum interference device (dc-SQUID) magnetometer for high sensitivity capable of detecting the perpendicular electron spin polarization induced by an in-plane scanned external magnetic field and applied microwave frequency by measuring the DC field to perform EPR spectroscopy at a minimum detectable number of polarized spins of 10^6 spins [51].

An optically detected magnetic resonance (ODMR) system is another high-sensitivity detector for neutrino flux that serves as at least one of a magnetometer and an EPR instrument.

An ODMR detector uses light and microwaves to monitor electron spin states of reporter materials like nitrogen-vacancy (NV) centers in diamond having its surface coated with a composition of matter comprising molecular hydrino. At least one of the neutrino-interaction dependent external magnetic field and EPR spectral emission profile of molecular hydrino is recorded by scanning at least one of the frequency of applied microwaves or an optional magnetic field to create resonance with at least one of the electron spin flip transitions of molecular hydrino and the NV center wherein molecular hydrino is a $S=1/2$ system and the $S=1$ spin states of the NV center having $m_s = +1$ and $m_s = -1$ sub-levels are degenerate in the absence of a magnetic field and Zeeman split when the system comprises an applied field. The NV sensor works by monitoring changes in the NV center's fluorescence from an optically pumped spin state when at least one of the microwave frequencies and optional magnetic field are scanned to cause a resonant spin transition of the NV center recoded as a change (e.g. a decrease) in the NV center's fluorescence. At least one of the magnetic field and microwave contributions from molecular hydrino at the NV center perturb or shift the parameters of the NV center resonance as reported by the center's fluorescence behavior. The sensitivity may be increased by modulation of at least one of the microwave frequencies and the applied optional magnetic field as well as application of other known EPR techniques that may further allow simplification of the system. Purser et al. [52] report on a EPR system that requires neither direct microwave manipulation of the NV spin nor spectral overlap between NV and target (e.g. molecular hydrino) spin resonances, thus enabling broadband detection via non-resonant coupling attributable to a two-phonon process that relaxes NV spin proximate to the fluctuating dipole moment of the target spin wherein the sensitivity is determined by the dipole-dipole coupling strength. Another technique to perform EPR using an NV detector rather than an RF detector is to use microwave pulsed EPR (e.g. using $\frac{\pi}{2}, \pi$ pulses). Kong et al. [53] report on using double electron-electron resonance (DEER) pulsed EPR at zero field. NV center detection of EPR signal at zero field is very favorable for recording neutrino interaction signals. Zero field is the region where the spectral intensity of EPR signals shifted by neutrino interaction is favored, and in many cases the intensity in the zero-field region dominates the spectrum over the entire range (e.g. Figures 8A-B, 10, 12-19, 24-25). Commercially produced microminiaturized ODMR detectors (nanometer scale for the NV component) may operate at room temperature and a magnetic sensitivity of sub-picotesla (e.g. $0.47 \text{ pT}/\sqrt{\text{Hz}}$ or lower) with intrinsic spin relaxation and coherence response times enabling measurement cycles of hundreds of nanoseconds [48, 52-56].

Another optical magnetometer to record the neutrino flux, a spin-exchange relaxation-free (SERF) magnetometer, exploits circularly polarized pump lasers to align atomic spins of

vapor phase alkali atoms and a linearly polarized probe laser to measure optical rotation caused by the external magnetic fields of a composition of matter comprising molecular hydrino as it interacts with the neutrino flux. Faraday and Mu-metal shields may essentially eliminate electromagnetic and magnetic fields, respectively, such that the neutrino-interaction-dependent zero field spin flip transitions of molecular hydrino may be detected. SERF detectors are also commercially available, have been miniaturized to millimeter scale, have ultra-high femtotesla sensitivities at room or moderate temperatures, and millisecond response times.

Conclusions

Spin $\frac{1}{2}$ $H_2(1/4)$ is observed by EPR spectroscopy at a predicted slightly downfield shifted g factor relative to that of a free electron with fine structure comprising spin orbital coupling between the paired and unpaired electrons of its MO as well as fluxon linkages during the spin flip transition. The excitation of the fine structure transitions is assigned to $C\nu B$ absorption wherein the peaks were extraordinarily sharp when $H_2(1/4)$ behaved as an isolated gas at vacuum when trapped in a $Ga(O)OH$ matrix. The complex neutrino excited fine structure pattern collapsed into a predicted sharp triplet due to the Paschen Beck effect. In all other studied matrices formed as a product of reactants comprising sources of H and HOH catalyst that yielded entrapped $H_2(1/4)$, the peaks were very broad and downfield shifted by 500 G due to the formation of an end-to-end linear van der Waals electric dimer ($[H_2(1/4)]_2$) along the semimajor axis of the $H_2(1/4)$ MO with a spin of $\frac{1}{2}$ matching theoretical predictions. Two dimers then formed a side-to-side dimer-of-dimers along the semiminor axis by dipolar interaction resulting in a spin of zero at cryogenic temperatures. The dimer of dimers is an interstitial ‘defect’ of the host material. A magnetic phase transition sets in around a temperature of ca 107 K above which decoupling of dipolar interaction increasingly affords paramagnetic single dimers. The hydrino dimer signatures and temperature dependency are very significant. The results further indicate the production of $H_2(1/8)$ with a downfield shift of 4028 G, significantly greater than that of $H_2(1/4)$. The observation of the formation of a dimer between molecular hydrino and H_2 ($H_2(1/4)-H_2$) and the temperature dependence of hydrogen release explains the massive amounts of hydrogen observed from salts containing hydrino. These salts are not known to absorb any hydrogen and indicate a new very important technology comprising the conversion of common salts to hydrogen storage materials which are potentially of great industrial value. The high magnetism of some of the samples approaching ferromagnetism of otherwise diamagnetic matrices indicate the further potential commercial value of these materials as replacements for

rare earth and other strong magnets with the potential for production of super magnets, orders of magnitude stronger than those of any known magnet.

The very broad nature of the peaks extended to zero field and showed significant intensity starting at zero field in both parallel and perpendicular modes which confirmed the broadening mechanism of neutrino excitation of fine structure levels and other neutrino-absorption dependent mechanisms of peak broadening. These include a short state lifetime with a corresponding broad natural width of a spin flip transition accentuated by neutrino mediated spin-orbital coupling and close-proximity magnetic dipole dimer interactions, other neutrino excitation-mediated mechanisms involving the matrix morphology, temperature effects, and neutrino excitation of spin-orbital coupling levels of a member or a dimer with intramolecular angular momentum transfer to create orbital angular momentum in the other member of the dimer which further added to dipole-dipole interaction between the two members of the dimer resulting in further downfield shifts and broadening. An observed specific example is the $H_2(1/4)$ - H_2 dimer having observed downfield EPR shifts of 60 G and 132 G corresponding to allowed induced H_2 magnetic moments of $0.5\mu_B$ and μ_B with allowed spin-orbital coupling quantum numbers of 0 and 2, respectively.

Other neutrino absorption dependent mechanisms of EPR shifts and broadening for $[H_2(1/4)]_2$ dimers include alteration of the van der Waals charge density and bonding, intra-dimer and inter-dimer bonding, vibrational and librational excitations, and multimer formation beyond dimers. The sharp fine structure lines of $H_2(1/4)$ trapped in a Ga(O)OH matrix as well as the unique shifts, temperature dependence, extraordinary broadening, zero field signal, significant parallel mode signal starting at zero field, peak broadening with a transition in crystal morphology, temporal changes of EPR spectra due to accumulated changes in fine structure state populations, and other aspects of molecular hydrino monomers, dimers, and tetramers match theoretical predictions involving the absorption of neutrinos for excitation of the observed peaks. The EPR spectrum recorded at 275.7 GHz allowed the determination of the energy range of the neutrino excitations which matched the anticipated energy range and spectrum of the $C\nu B$ flux allowing the $C\nu B$ flux to be detected and characterized for the first time. Some of the effects that alter the neutrino absorption cross section at any given B flux could be selectively observed by recording the unique temperature dependence of the EPR spectrum. It was also shown that the neutrino absorption of one material comprising $H_2(1/4)$ - H_2 dimer blocked the $C\nu B$ flux incident another material comprising $H_2(1/4)$ - H_2 dimer that it encased, thereby eliminating the corresponding EPR signature in the encased material. The ability to control the otherwise constant $C\nu B$ flux enables a technology to send and receive time variable neutrino flux that encodes the telecommunication signals. As discussed in the Transmitter and receiver technologies section, the adaptation of existing technologies are enabling of the encoding and

decoding of the unattenuated and undispersed telecommunications signals in the ubiquitous cosmological neutrino background to provide inherently powered, unlimited bandwidth communication anywhere on the Earth, undersea, and throughout space at line of site and light speed with a secure, low-power-consuming, handheld device.

2. Material and methods

2.1. Sample preparation

Generally, samples for EPR spectroscopy were produced in two different ways, ‘web samples’ by wire detonation to propagate a plasma explosion, and ‘mill samples’ by high-energy impact ball milling. In all cases nascent water was the catalyst.

Method-1 (plasma explosion): Zn samples comprising solid web-like fibers were prepared by wire detonation of an ultrahigh purity Zn wire in a H₂O vapor atmosphere in a rectangular cuboid Plexiglas chamber having a length of 46 cm and a width and height of 12.7 cm. Typically, a 10.2 cm long, 0.25 mm diameter metal wire was mounted between two Mo poles with Mo nuts at a distance of 9 cm from the chamber floor, a 15 kV capacitor (Westinghouse model 5PH349001AAA, 55 F) was charged to about 4.5 kV corresponding to 557 J by a 35 kV DC power supply, and a 12 V switch with a triggered spark gap switch (Information Unlimited, model-Trigatron10, 3 kJ) was used to close the circuit from the capacitor to the metal wire inside of the chamber to detonate the wire. The detonation chamber contained air comprising 20 Torr of water vapor controlled by a humidifier and a water vapor sensor. The water vapor served as a source of HOH catalyst and atomic H to form molecular hydrino. The high voltage DC power supply was turned off before closing the trigger switch. The peak voltage of about 4.5 kV was discharged as a damped harmonic oscillator over about 300 s at a peak current of 5 kA. A three-dimensional web of thin filaments or fibers formed from the atmosphere in about 3-10 minutes after the wire detonation. ‘Zn-web’ powder samples, Zn(OH)₂@H₂(1/4), were collected from the chamber, chamber floor and chamber walls, and stored in standard EPR quartz tubes. Additionally, Ga(O)OH@H₂(1/4) was prepared as base-stabilized web samples as previously described in detail [39]. Additionally, tin flake samples were prepared from a SunCell plasma reactor described in Mills PCT Application [44].

Method-2 (ball milling): the mixtures of inorganic compounds of variable composition shown in Table 1 as well as FeOOH provided a source of H and a source of O to form H and HOH and further served as a hydrino getter. EPR samples of FeOOH and Table 1 were prepared by high-energy ball milling of each mixture with a Retsch PM100 planetary ball mill using a 500 ml stainless steel jar with 5 stainless steel balls (Retsch Inc, Newtown, PA), typically run for 3 to 5h at 600 RPM. Tin, KOH, KI, ZnO and Cu(OH)₂ served as control samples. KHCO₃-KCl (50/50 wt%) was ball milled for 5 hours at 300 RPM using 5 SS balls with an Across PQ-N2 Planetary ball mill. KOH-CsI-Ga metal (42.5/42.5/5 wt%) was ball milled for 6 hours at 600 RPM using 5 SS balls and a Retsch Planetary ball mill. KOH-KI-Ga metal (18/72/10 wt%) was ball milled for 12 hours at 600 RPM using 5 SS balls in a Retsch Planetary ball mill.

2.2 Spectroscopy

X-band spectra were recorded at 9.4-9.9 GHz with a Bruker EMX-plus spectrometer using the high-sensitivity ER4119HS resonator. The microwave frequency was monitored with a 20 GHz Hewlett Packard 5350B frequency counter. The modulation frequency was always 100 kHz, the temperature was ambient (20 °C) unless indicated otherwise, the modulation amplitude was 10 Gauss, and the microwave power was -10 dB (= 10 mW). Temperature-dependent studies were done using the standard ER4102ST resonator and a home-built helium flow system [57]. Background signal free quartz for sample tubes and for the flow dewar were obtained from QSiL GmbH Quarzschmelze Ilmenau, Germany. Sample temperature was measured with a carbon-composition thermometer [58] placed inside the sample just above the cavity measuring area. Q-band data were taken at ca 35 GHz with a Varian E-line spectrometer with the recorder y-axis amplitude and the x-axis micro switches connected to a NI 6001 data acquisition interface (National Instruments) for 20 kS/s digital storage using a LabVIEW program. A WR-28 waveguide 566-series cross guide directional coupler combined with a 410-series waveguide to coax transition (Millimeter Wave Products) were built into the main microwave path of the Q-band bridge to monitor the frequency with a 46 GHz Hewlett Packard 5352B frequency counter. L- and S-band spectra at ca 1.4 and 4.1 GHz were collected with the home-built broadband extension to the Bruker EMX-plus spectrometer, as described in detail in [59-60].

Acknowledgements

Reproduction of hydrino-EPR by Bruker analytical scientists (Billerica)

Collection of 276 GHz spectra by Dr Peter Gast (Leiden)

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