Research Essay

Can Panpsychism Become an Observational Science?

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Abstract

In 2011, I was invited to participate in a symposium at the London headquarters of the British Interplanetary Society. The subject of the symposium was the contributions of philosopher/science-fiction-author Olaf Stapledon. Instead of concentrating on the many technological projections in Stapledon's masterwork *Star Maker*, I elected to investigate whether there is any evidence to support his core metaphysics—that the universe is in some sense conscious and that a portion of stellar motion is volitional (as an alternative to Dark Matter). Stars do not possess neurons or tubules, but the spectral signatures of cooler stars such as the Sun reveal the presence of simple molecules. A universal proto-consciousness field congruent with vacuum fluctuations could interact with molecular matter via the contribution of the Casimir Effect to molecular bonds. Surprisingly, there is observational evidence that cooler stars move somewhat faster around the galactic center than their hotter sisters. This velocity difference, called Parenago's Discontinuity, occurs in the stellar temperature distribution where molecular spectral lines become apparent. Data from Allen's Astrophysical Quantities and the European Hipparcos space observatory reveal that Parenago's Discontinuity is found in main sequence stars as far as ~260 light years from the Sun and in giant stars at distances greater than 1,000 light years. As discussed in the paper, local explanations for Parenago's Discontinuity seem inadequate. Gaia, a successor to Hipparcos, is currently on station observing positions and motions of ~1 billion stars in our galaxy. If the Discontinuity is a galaxy-wide phenomenon, the volitional star hypothesis will be advanced. One way that a minded star could alter its galactic trajectory is by the emission of a uni-directional jet. Such jets have been observed in young stars. Future work will hopefully show how uni-directional jets correlate with star temperature and distance from the galactic center. It is therefore not impossible that panpsychism can emerge from philosophy to become a subdivision of observational astrophysics.

Keywords: Panpsychism, Parenago's Discontinuity, stellar volition, self-organizing universe, anomalous stellar motions, dark matter.

Introduction

Since this paper is about methods to verify (or falsify) the existence of universal consciousness, the evolution of my thoughts on this matter might interest some readers. How is it that someone best known as a student of interstellar travel emerged as a consciousness researcher?

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A reviewer of one of my early papers on interstellar travel was Evan Harris Walker (1935-2006), the author of an early theory of quantum consciousness (Walker, 1970, 1999). Harris, as his friends called him became a mentor, coauthor and friend. Although our collaboration was more along the lines of plasma physics, I found his quantum-consciousness theory fascinating.

Perhaps because of the success of the papers Harris had assisted with, I coauthored *The Starlight Handbook* in 1989 (Mallove and Matloff, 1989). Now established as an "expert" in the infant field of interstellar-propulsion research, I was asked by Apollo 11 astronaut Buzz Aldrin to serve as a scientific consultant on a science-fiction novel (Aldrin and Barnes, 1996). After finishing work on the spaceships in the novel, Buzz (who was aware of my early training in planetary atmosphere analysis) asked me to check whether the hydrogen-helium atmosphere of a Jupiter-like giant planet could survive if the planet was situated at the Earth's distance from its Sun-like star. Although I was initially very skeptical since then-standard models of solar system formation seemed to rule out such a possibility, I searched through the literature and located the appropriate equation (Jastrow and Rasool, 1965).

To my amazement, Buzz was correct. The planet's atmosphere is stable for billions of years. Since I was at the time working as a consultant and adjunct professor, I did not challenge the existing physical paradigm by submitting my results to a mainstream journal. Since "Hot Jupiters" were discovered shortly before the novel was published, I am now credited with predicting the existence of such worlds. Another friend, Howard Bloom (2011) states that the role of a scientist is to publish his/her results, regardless of consequences.

In 2010 or 2011, I was conducting an Astronomy 2 lecture on Dark Matter and anomalous stellar motions at New York City College of Technology. An undergraduate liberal arts student raised his hand and stated that "dark matter is bunk". He justified his position by describing the 7-decade unsuccessful search for this material in the effort to explain the fact that stars in the outer portions of spiral galaxies (such as our Milky Way) move faster than they should. In his opinion, this and other observational anomalies reveal astrophysics to be in an analogous position to theoretical physics in the years before Einstein's publication of Special Relativity in 1905.

Perhaps because I am a Fellow of the British Interplanetary Society, I was invited to participate in a symposium on the work of science-fiction-author/philosopher Olaf Stapledon to be conducted at the society's headquarters in London during October 2011. In his 1937-vintage masterwork *Star Maker*, Stapledon makes many technological and societal projections regarding the future evolution of technological life. For this reason, his work is cited by many scientists, engineers, and futurists. But perhaps because of the personal evolution outlined above, I elected to investigate instead whether there is some scientific validity behind his core metaphysics—that the universe is conscious and a portion of stellar motion is volitional. This work was published in a 2012 issue of *The Journal of the British Interplanetary Society* (Matloff, 2012).

A "Toy Model" of Universal Consciousness

Most models of quantum consciousness do not apply to a molecule-bearing star. Walker's (1970) model invokes the phenomenon of quantum tunneling operating on particle wave functions in the potential well existing between neuronal synapses. A more recent model that has received some experimental validation as reviewed by Matloff (2015). With contributions by Margolis (2001) and Hameroff and Penrose (2014), this approach considers quantum entanglement at the scale of microtubules within the brain.

I don't claim to be an expert on the stellar interior. But it is a pretty good bet to assume that neurons and synapses are not present in stars. Since some stars have molecules, a model of the interaction between a universal field of proto-consciousness and molecular model was applied. This "toy model" (Figure 1) is based in part upon the work of Bernard Haisch (2006).

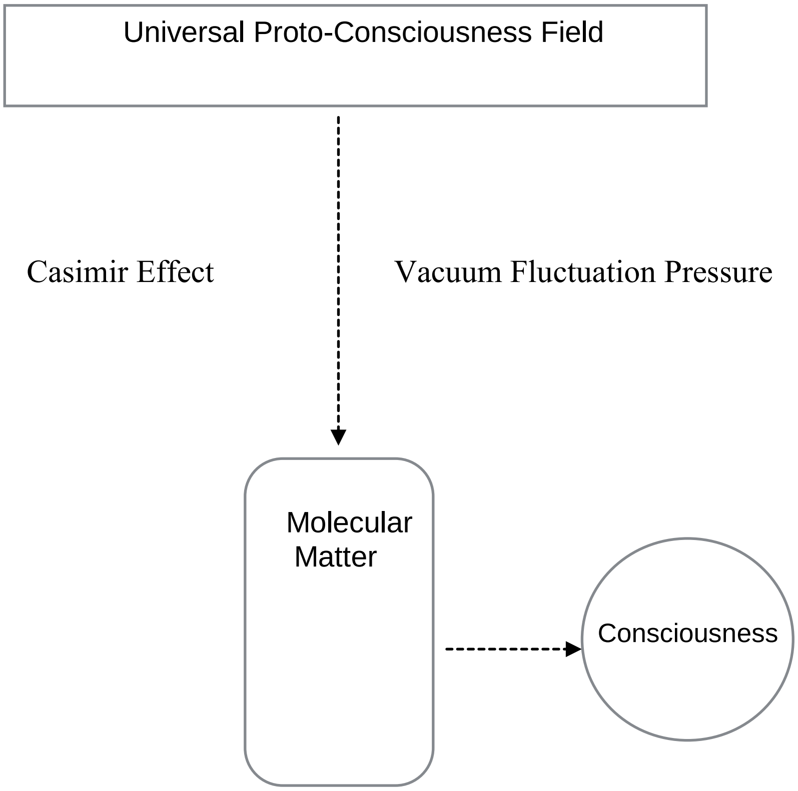


Fig. 1. A Toy Model for a Molecular Basis of Consciousness.

In this model, a universal field of proto-consciousness is congruent with the fluctuations in the universal vacuum. As described by Genz (1999), it has been known since 1948 that a significant fraction of the Van der Waal molecular bond is due to vacuum fluctuation pressure—the so-called Casimir Effect. Essentially, the separation between atoms in molecules is so small that some vacuum fluctuations are not allowed between atoms. It is not unreasonable that vacuum fluctuations play a role in consciousness. After all, the most creative incident in the universe—the Big Bang—is thought to be a stabilized vacuum fluctuation.

There are two prevailing schools of thought regarding the origin of consciousness. Perhaps the most prevalent view is Epiphenomenalism—the doctrine that mental events are all due to physical properties of the brain. In this view, consciousness might arise in humans and higher animals as a result of neuronal complexity. A competing view, panpsychism, has been described by Chalmers (2015), Nagel (2012) and others and seems to be gaining ground among philosophers. According to panpsychism, consciousness is built into the fabric of the universe. Freeman Dyson, one of the most significant mathematical physicists of the late 20th and early 21st centuries, clearly favors panpsychism. He writes, in Dyson (1988) that mind seems to play a role in at least three levels in the universe—the quantum level of elementary particles, the human level, and the cosmological level at which universal laws seem fine tuned to allow the emergence of life.

We are postulating here that mind (or consciousness) may play a role at the stellar level. Evidence is reviewed later in this essay as is future observations that may verify or falsify the hypothesis.

Molecules in Stars

The next step is to consider what stars possess molecules and which layers are likely to contain molecules in these stars. Since this essay is designed for an interdisciplinary audience, this consideration begins with the Hertzsprung-Russell Diagram, one of the basic classification tools of stellar astrophysics (Figure 2).

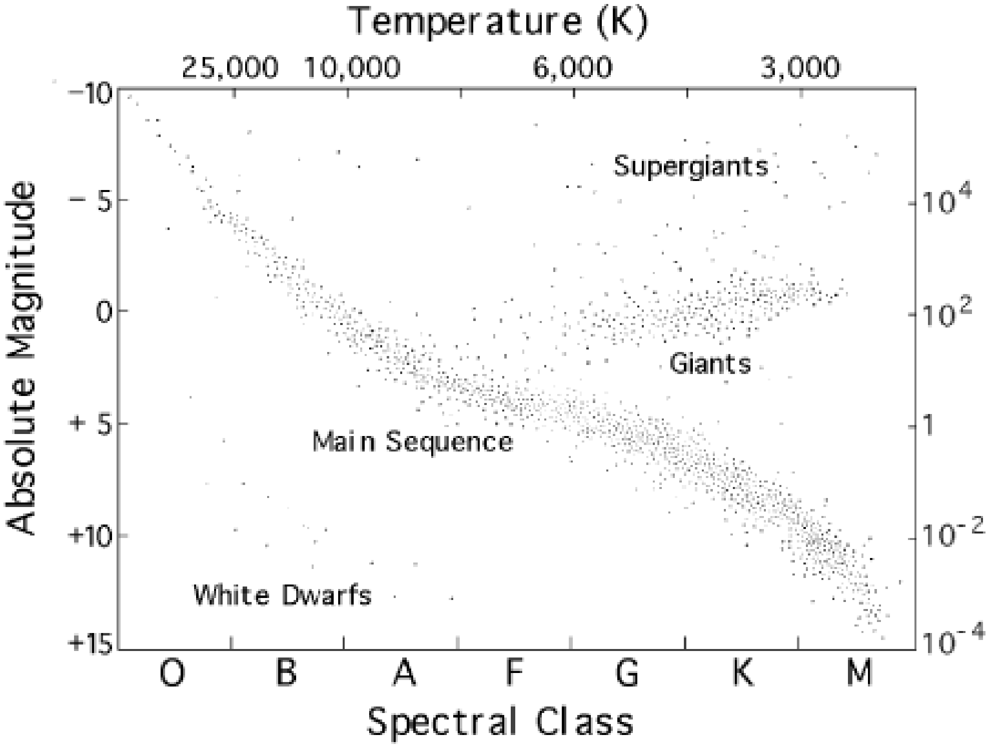


Fig. 2. The Hertzsprung-Russell Diagram (courtesy NASA).

To understand this diagram, look first at the left and right vertical axes. Luminosity is relative to the Sun. The Absolute Magnitude scale is a logarithmic metric of star brightness, corrected for distance (as opposed to Apparent Magnitudes which are uncorrected for star distance). Brighter stars have a lower absolute magnitude than dim stars.

Although most stars fuse hydrogen to produce helium and energy and therefore have a deep-interior temperature measured in tens of million degrees Kelvin (K), hot, luminous stars have an effective surface (photosphere) temperature of about 25, 000 K. The dimmest, coolest stars have a photosphere effective temperature less than 3,000 K.

The Spectral Classes listed on the lower horizontal axis correspond to star photosphere temperature and color. Hot O stars are blue, cool M stars are red. The spectral classes are further sub-divided. From left to right, A stars (for example) are divided as A0, A1, A2, …A9.

Stars are also classified according to Luminosity Class. Major luminosity classes include Super Giants (I), Giants (III), Main Sequence Dwarfs (V) and White Dwarf (WD) stars. Most stars, including the Sun, obtain their energy from hydrogen fusion and reside on the main sequence. Hot O stars are the most massive but only reside on the main sequence for a few million years. The Sun, a G0V star, is about half-way through its 10 billion year main-sequence lifespan. As a star ages on the main sequence, its luminosity gradually increases.

Hot, short-lived, massive O and B stars leave the main sequence to expand into super giants. At the end of this phase, they often suffer enormous supernova explosions and shrink to become white dwarfs. Cooler stars expand to become giants and then ultimately contract relatively peacefully to the white dwarf phase. Readers interested in more information on stellar evolution are encouraged to consult an astronomy text such as Chaisson and McMillan (2008).

Stellar Color Indices

Although the Hertzsprung-Russell Diagram is a very powerful star classification scheme, the O, B, A, F, G, K, M spectral class scheme is not adequate for quantitative work. For such applications, astrophysicists often use the (B-V) color indices of stars. These are derived from measurements of star apparent magnitude to the optical wavebands centered in the blue (B) and yellow (V) spectral region [Dufay, (1964), Johnson, 1963)]. The (B-V) color index is lower for hot, blue, massive stars and higher for cool, red, lower-mass stars.

Working with (B-V) color index measurements of thousands of stars, astrophysicists have tabulated average color indices for various spectral classes. One such table for main sequence stars is presented as Table 1 (Drilling and Landolt, 2000). Similar tables exist for giant and supergiant stars.

Note in Table 1 that the numerically lowest (B-V) color indices are for hot, blue, massive, short-lived O5 stars. The highest are for cool, red, low-mass, long-lived M5 stars.

Using the (B-V) color index in place of star spectral class allows for a more quantitative presentation of stellar data. As shown below, this leads to a nice pictorial representation of star kinematics anomalies.

Table 1. (B-V) Color Indices For Various Main Sequence Star Spectral Classes

Star Spectral Class	(B-V) Color Index
O5	-0.33
B0	-0.30
B5	-0.17
A0	-0.02
A5	0.15
F0	0.30
F5	0.44
G0	0.58
G5	0.68
K0	0.81
K5	1.15
M0	1.40
M5	1.64

Where Molecules Are Located in Stars and Which Stars Have Molecules

The serious study of molecular stellar signatures in stars began in the 1930's. Although molecular spectra can serve as a diagnostic tool in the study of stellar outer layers and circumstellar envelopes, molecular stellar spectroscopy has played a minor role in recent decades (Tsuji, 1986).

The stellar interior is a very hot place. It therefore might come as a surprise to learn that the spectral signatures of numerous molecular species have been observed in various stars. Molecules detected in the spectra of the Sun (a G2 V star with an effective photosphere temperature of 5777 K (Livingston, 2000) and sunspots include AlH, AlO, BH, BO, CH, CH+, CN, CO, CuH, MgF, MgH, MgO, NH, O2, OH, ScO, SiH+, SiN, SiO, SrF, TiH (Nicholls, 1977). Simple molecules including CH and CN are seen in other G and K stars. Cooler stars have more complex molecular signatures (Nichols, 1977).

As discussed by Tsuji (1986), quantitative spectral analysis of molecular spectra is much easier in the bright, nearby Sun than in more distant stars. On problem in interpreting stellar molecular spectral data is line broadening. Another is the huge number of spectral lines for some molecules, which results in an overlap of spectral bands. Stellar layers may be less homogenous than some researchers have assumed and starspots can affect the molecular spectra in adjacent, hotter regions (Tsuji, 1986).

Because of the Sun's high photosphere temperature and the fact that even a cooler K2 star has a photosphere temperature of about 5000 K, it seems likely that stable molecules will be found in a low-optical-thickness reversing layer above the photosphere and below the chromosphere (Novotny, 1973). The mass of the molecular envelope in this layer is estimated to be between one-ten-thousandth and one-millionth of the Sun's mass in some giant stars (Tsuji, 1986). In the Quiet Sun, the temperature minimum in this layer is about 600 km above the photosphere (Averett, 2003). Blitzer has estimated the CN excitation temperature in this layer to be 4490 +/- 100 K. Other researchers cite temperatures in the range 4000-4670 K (Blitzer, 1940).

It is interesting to note that Erich Jantsch (1980), in his ground-breaking discussion of the evidence for a self-organizing universe, touches on the subject of stellar consciousness. Arguing on thermodynamic grounds, Jantsch concludes that the likely location for consciousness is in the upper layers of a star—exactly where molecules are found in cool stars.

Some researchers have used stellar molecular spectral observations to model stellar interiors. Russell (Russell, 1934) investigated the role of relative element abundances. For giant K and M stars with more oxygen than carbon, CN abundance and CH abundance respectively peak at temperatures of 3877 K and 4200 K. For main sequence (dwarf) K and M stars with more oxygen than carbon, CN peaks at 4383 K and CH peaks at 4800 K (Russell, 1934).

For giant stars richer in carbon than oxygen, such abundance peaks with temperature are not as distinct. In dwarf stars richer in carbon than oxygen, CN abundance peaks near 3252 K and CH abundance peaks near 3150 K. For giants with equal amounts of carbon and oxygen, the temperatures for peak abundances of CH and CN are respectively 3877 K and 3055 K (Russell, 1934).

Russell's (1934) model also predicts that molecules are rare or non-existent in giants earlier than F4 and in dwarfs earlier than F7. In dwarfs, CH and CN maximum abundance occurs respectively in spectral classes K2 and K4. In giants, CH and CN maximum abundance occurs respectively in spectral classes G7 and K1. For temperatures greater than 4500 K, the predicted CN abundance is slightly less in giants than in dwarfs (Russell, 1934).

Molecular Line Width Observations for a Small Stellar Sample vs. (B-V) Color Indices

Rense and Hynek (1937) published a study of the G Band in the spectra of 25 stars. The G band extends 4203-4317 Angstroms, in the extreme blue region of the visible spectrum. This band can be used as an approximate measure of CH abundance since some CH spectral absorption lines are within this band. They reported that the G band is somewhat more pronounced in giants than in dwarfs. Partial pressure is about 80X greater in F8 dwarfs than in G0 giants and association of atoms into molecules is 4.5X greater in F8 dwarf stars than in G0 giants. For dwarf stars hotter than F5 in their observational sample, all G band spectral lines are atomic. According to Rense and Hynek (1937), CN spectral lines used were 4192.57 and 4197.10 Angstroms. CH spectral line used were 4293.12 and 4303.94 Angstroms.

Table 2 is a partial representation of the Rense/Hynek (1937) results. Only single stars are included in Table 2, with the exception of η Cor., which is a binary consisting of two nearly identical G dwarf stars. Variable stars are also omitted. The BS# designations are from Hoffleit's (1964) catalogue. Spectral and luminosity classes and the (B-V) color indices are from Johnson et al's (1966) photometric observations of many bright stars , except where otherwise noted. The (B-V) of the Sun is from Croft et al. (1972).

A subset of the data presented in Table 2 was used to prepare the graphical representation of G line width vs. (B-V) color index for giant/bright giant stars (luminosity classes III and II) and dwarf/sub-giants (luminosity classes V and IV) presented in Fig. 3. Supergiants were not included because I was not able to locate contemporary studies of the stellar kinematics anomaly to be discussed below (Parenago's Discontinuity) in this stellar luminosity class.

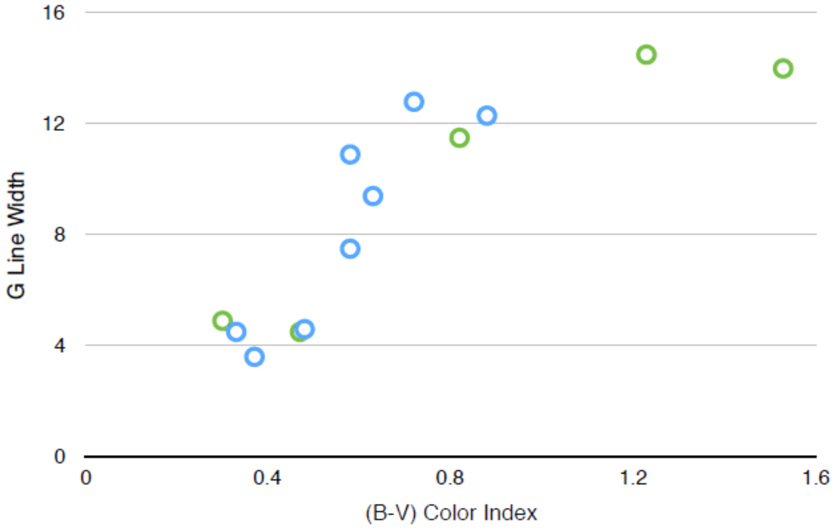
At least one other team (Swings and Struve, 1932) obtained similar but less quantitative observational results . Investigating spectra of 28 stars for CH and 9 stars for CN., they found the hot-star limit for CH and CN is F8 stars, with photosphere temperatures of ~6500 K. In only one of eight F5 stars was a faint indication found for CN. CN becomes progressively stronger in stars cooler than the Sun (Swings and Struve, 1932).

Table 2. CN Molecular and G Equivalent Absorption Observational Estimates from Rense and Hynek (1937). G Line Absorption is a Measure of CH Abundance. Unless Noted, Spectral/Luminosity Class and B-V are from Johnson et al, (1966), Unless Otherwise Noted.

Star Name	BS#	Spectral/Luminosity Class	(B-V)	G Line Width	CN Relative Absorption
η Lep.	2085	F0 V	0.33	4.5	0
20 Can. Ven.	5017	F0 II-III	0.30	4.9	0
81 Leo.	4408	F2 V$^+$	0.37$^+$	3.6	>0
53 Vir.	4981	F5 III-IV^{++}	0.47^{++}	4.5	>0
τ Boo.	5185	F2 V	0.48	4.6	>0
α Per.	1017	F5 I	0.48	6.0	>0
η Cas.	219	G0 V	0.58	10.9	0
Sun^{+++}		G0 V	0.63	9.4	1
η Cor.	5727/5728	G2V (G1V + G3V)	0.58	7.5	2
β Lep.	1829	G5 III	0.82	11.5	2
σ ^{2} Eri.	1325	K1 V	0.82	9.6	1
ε Gem.	2473	G8 I	1.40	13.2	3
ε Eri.	984	K2 V	0.88	12.3	>1
τ Ceti	509	G8 V	0.72	12.8	1
α Boo.	5340	K2 III	1.23	14.5	3
ι Aur.	1577	K3 II	1.53	14.0	>2
α Ori.	2061	M1/2 I	1.84	10.7	3

BS# are Bright Star Numbers from: D. Hoffleit, Catalogue of Bright Stars, 3rd Revised Ed., Yale Univ. Observatory, New Haven, CT (1964).
Variable and multiple stars from Rense/Hynek (1937) list are omitted except for η Cor., which is a double with nearly identical members.
+ : www.inis.jinr.ru/sl/tcaep/astro/constell/11250099.htm. Also in Wikipedia.
++ : www.inis.jinr.ru/sl/tcaep/astro/constell/13120006.htm. Also in Wikipedia.
+++ : Croft et al. (1972).

Fig.3. G Line Width vs. (B-V) Color Index for Rense/Hynek Stars. Green Points: giants & bright giants. Blue points: dwarfs & sub-giants



Because of the small stellar dataset, there is plenty of room for additional research in this field. But it seems safe to conclude that the spectral signature of molecules first appears in late-F stars somewhat hotter than our Sun, at a (B-V) color index value of about 0.55.

Anomalous Stellar Motions: Dark Matter & Parenago's Discontinuity

One would think that stars revolve around the center of our galaxy in a similar to the Keplerian motion of planets around the Sun. But since the 1930's observational evidence has not supported this assumption. Instead, stars further from the galactic center revolve faster than those closer in. In respect to its motion or structure, a spiral galaxy such as our Milky Way resembles the motion of a wheel's spokes more than that of a planetary system.
Dark Matter: MACHOs, WIMPS, and MONDS

Astronomy is a conservative discipline. In light of their success in explaining anomalous planet motions within our solar system, astronomers developed a similar hypothesis to explain anomalous stellar motions. This concept, dubbed "Dark Matter", proposes that stellar motions (and the stability of galaxy clusters) is influenced by the presence of a mysterious, invisible form of matter that can only be detected by its gravitational effects. More than 65% of the matter in the universe hypothetically consists of this material.

As reviewed in Matloff (2015), there are two basic types of hypothetical dark matter. Massive Compact Objects located in the galaxy's halo (MACHOS) are one candidate. Perhaps there are huge numbers of invisible black holes, neutron stars, white dwarf stars or stranger stellar mass objects in the outer reaches of the spiral galaxies.
There are two major objections to the MACHO concept. First, the globular star clusters in the halo of the spiral galaxies would be disrupter by this huge population of massive objects—and such a disruption has never been observed, Second, there would be many more gravity lens effects than have been observed.

An alternative to the MACHO concept is WIMPS—weakly interacting massive particles. WIMPS are thought to be sub-atomic particles perhaps left over from the Big Bang. They come in two varieties—cold and hot. Cold, low-velocity WIMPS are the favorites of many astrophysicists since these seem necessary to explain the motions of galaxy clusters. Hot, high-velocity WIMPS appeal to accelerator physicists since these are more in keeping with the predictions of their Standard Model.

But there are objections to the WIMPS concept as well. First, if such a large fraction of the universe's mass consists of these particles, and they gravitationally affect star motion, they should pool around massive objects such as stars. As reviewed in Matloff (2014), there have been many failed attempts to observe anomalous motions within our solar system or near it that might be used by a WIMPS concentration.

Perhaps to relieve their frustration with the other alternatives, some astrophysicists have considered Modifications to Newtonian Dynamics (MONDS). They are correct in the observation that there is no known reason why Newton's formula of Universal Gravitation should predict a force that exactly varies with the inverse of the square of the distance between the gravitating bodies. But unfortunately, no modification to Newtonian-Einsteinian gravitation has been suggested that applies to motions in both the outer ranges of spiral galaxies and galaxy clusters.

Parenago's Discontinuity

As I discuss in the Introduction, I began to investigate stellar kinematics partially in response to the eight-decade failure to solve the Dark Matter Mystery. If the reason for anomalies in stellar motion is stellar volition, as suggested by Olaf Stapledon in *Star Maker* and if molecular consciousness via the Casimir Effect results in minded stars, relatively cool stars with molecules should move differently than their hotter sisters.

Although I expected to find nothing supporting this concept, a literature search revealed the observational work of Pavel Parenago. According to the Wikipedia page describing his contributions (http://en.wikipedia.org/wiki/Pavel_Petrovich_perenago**)**, Parenago (1906-1960) was a Soviet-Russian observational astronomer. An asteroid and a crater on the lunar far side are named after Parenago who received the Order of Lenin, was a Corresponding Member of the

Soviet Academy of Sciences and directed the Department of Stellar Astronomy at Moscow State University.

Pavel Parenago may have realized that his observational contribution described below was in contradiction to the then-prevailing Soviet ideology of orthodox materialism. To perhaps insulate himself from a long stay in a cold climate at government expense, he dedicated a book he authored to the most highly evolved human: Comrade Josef Stalin!

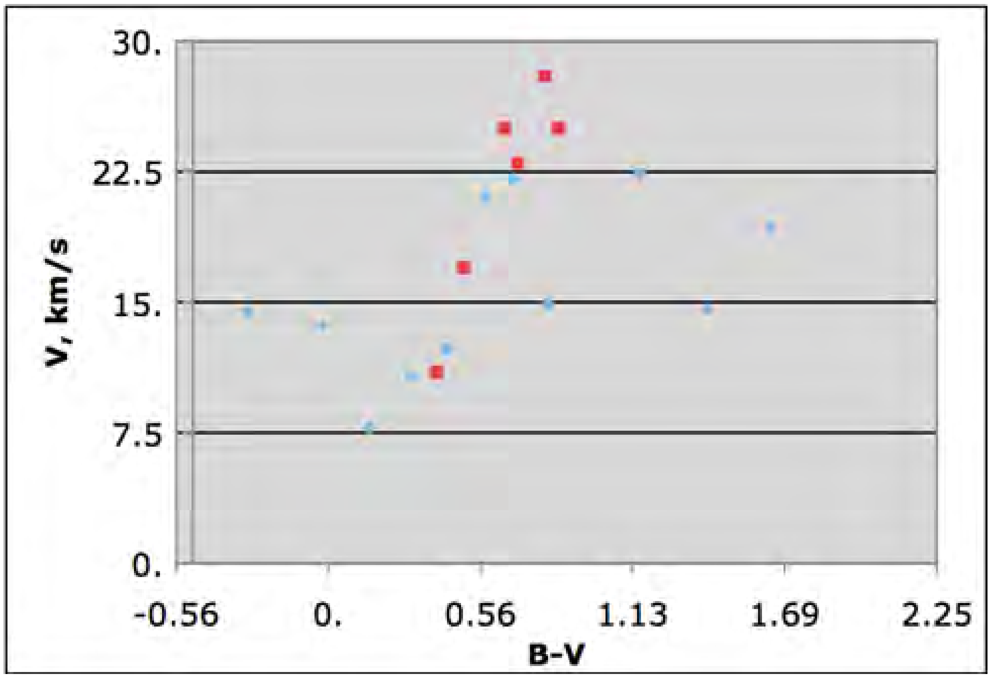


Fig. 4A. Parenago's Discontinuity for Main Sequence Stars out to ~260 Light Years. Diamond Data Points are from Gilmore & Zelik (2000). Square Data Points are from Hipparcos Space Data (Binney et al, 1997). The vertical axis is star velocity around the galactic center.

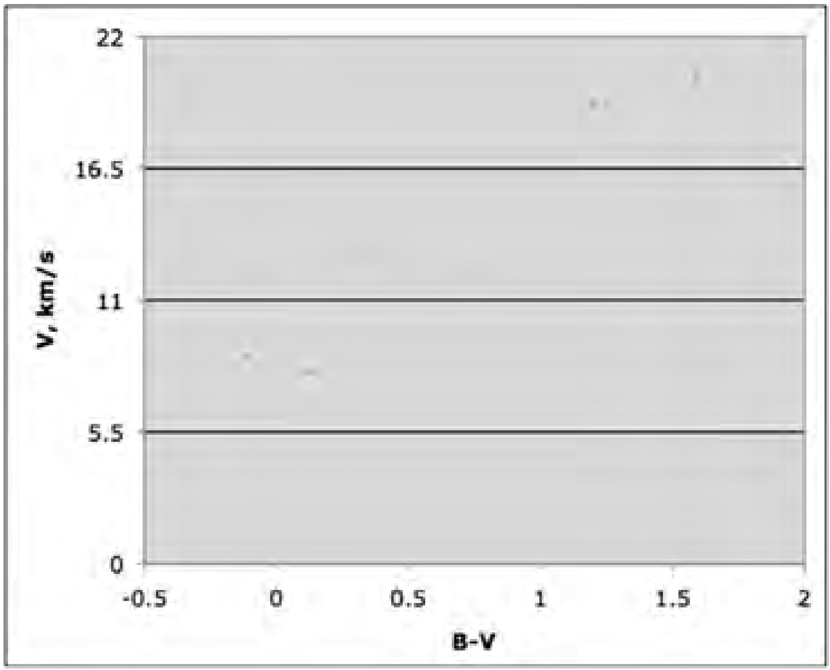


Fig. 4B. Parenago's Discontinuity for Giant Stars Out to >1,000 Light Years (Branham, 2011).

Parenago's Discontinuity refers to his discovery that cool, less massive stars circle the galaxy's center a bit faster than hot, massive stars. To check his results in the preparation of Matloff (2012), I used stellar kinematics data for main sequence dwarf stars as a function of (B-V) color index from two sources and data for giant stars from a third source (Fig. 4A). The Gilmore and Zelik (2000) data points are from Table 19.21 of the 4th edition of *Allen's Astrophysical Quantities,* one of the basic astrophysical sourcebooks. The Binney et al. (1997) data is from observations of more than 6,000 main sequence stars at distances out to about 260 light-years using the European Hipparcos space observatory.

Note from Fig. 4A that the velocity discontinuity occurs at about (B-V) = 0.45-0.5, very close to the (B-V) color index of F8 stars and the onset of molecular signatures in stellar spectra, as presented in Fig. 3. Also note the slight uptick in (B-V) for star with (B-V) less than about 0.3 in Fig. (4A). This is mirrored by the shape of the G-line-width curve in Fig. (3).

I prepared Fig. (4B) using data from Hipparcos presented by Richard L. Branham (2011) for thousands of giant stars out to heliocentric distances greater than 1,000 light years. As described in Matloff (2015), it was necessary to dig into Branham's earlier papers cited in Branham (2011) to prepare this figure, which validates Branham's (2011) claim that Parenago's Discontinuity is observable in giant stars at large heliocentric distances.

There are two reasons why Fig. (4B) is not as smooth as Fig. (4A). First, stellar distances beyond a few hundred light years from the Sun are less accurately determined than those of closer stars. Second, students of stellar kinematics compare star motions with the Local Standard of Rest, the centroid of motions in the sample. This works well for concentrated samples such as those in Fig. (4A) but may not be as accurate for stellar samples spread over thousands of light years.

We suggest here that the velocity difference in motion between cool stars with molecules and their hotter molecule-free sisters is related to a molecular basis for consciousness (as presented above) and stellar volition in molecule-bearing stars in concordance with Olaf Stapledon's assumption in *Star Maker*. But, as should happen in a healthy scientific discipline, two alternative explanations for Parenago's Discontinuity have been suggested. These are discussed in the next section.

Suggested Explanations for Parenago's Discontinuity—and Why They Fail

One possibility that has been considered relates to the fact that all stars start their lives in diffuse nebula—stellar nurseries that are rich in dust and gas. As described by Bochanski (2008), low-mass stars might be ejected at higher velocities from these galactic structures by gravitational interaction with stellar neighbors than higher-mass, hotter stars. This effect would produce greater dispersion in the velocity profiles of lower-mass stars (as has been observed) but why would it produce a systematic stellar velocity increase for low-mass stars in the direction of stellar revolution around the galactic center?

A second hypothesis, called Spiral Arms Density Waves, relates to the fact that dense diffuse nebula tend to be located in the spiral arms of galaxies such as our Milky Way (Binney, 2001, and DeSimone et al. 2004).

One way to appreciate Spiral Arms is to look at a Hubble Space Telescope image of a typical spiral galaxy. Such an image is reproduced below as Fig. 5. There are billions of such galaxies in the universe.

Fig. 5. Hubble Space Telescope Image of Spiral Galaxy M101 (courtesy NASA).

According to a modern version of Charles Messier's (1784) catalog of deep-sky objects (Jones, 1969), this object is less massive than our Milky Way with a mass of about 16 billion Suns. Its diameter is about 92,000 light years, much like that of the Milky Way and its distance is about 13-14 million light years.

Note in Fig. 5 the apparent difference in appearance between the spiral arms and the region between arms—the so-called Intercloud Medium. Star-forming nebula are found in the spiral arms. These have typical dust and gas densities >1000X greater than the density of the intercloud medium.

Imagine that a dense diffuse nebula drifts through a low-density region, such as our Sun's galactic vicinity. One possible explanation for Parenago's Discontinuity is that low-mass, high (B-V) stars are more likely to be dragged to a higher galactic velocity by this interaction than high-mass stars.

Unfortunately, there are at least two observational objections to the Spiral Arms hypothesis. The first involves the sizes and distribution of diffuse nebula in our galaxy.

In Matloff (2015), I tabulate sizes and distribution of the diffuse nebula within Jone's (1969} sample. Diffuse nebula in the Messier catalogue are too small to affect star motions over the ~500 light year diameter of the Binney et al. (1997) sample of Hipparcos-observed main sequence stars used to prepare Fig. 4A.

But there are only 104 deep-sky objects in Messier's compilation (Jones, 1969). In Matloff (2015a), this study is continued with two more extensive listings. One is a contemporary version of the late-18th century Herschel catalogue of more than 2,500 deep sky objects (Mullaney and Tirion, 2011). The second is an on-line version of the very extensiveNew General Catalog (www.atlasoftheuniverse.com/nebulae.html).

Application of these more extensive references yielded similar results to the earlier consideration of the Messier sample of diffuse galactic nebulae. From Matloff (2015a), the median diameter of diffuse nebulae is less than 20 light years. Only 10% of the sample have diameters greater than 100 light years. Within our galaxy, only the Eta Carinae circus-stellar nebula has a diameter greater than 400 lightyears. To find a diffuse nebulae large enough to accommodate the Binney et al (1997) sample of main sequence stars, we must look to an irregular satellite galaxy of our Milky Way—the Tarantula Nebulae (30 Doradus). Located about 200,000 light years from the Sun, this object has an estimated diameter of 800 light years (Burnham, 1978).

As well as agreeing on the paucity of large diffuse nebulae, analysis of these three sources leads to a similar conclusion on another point. Typical separations between neighboring diffuse nebulae are large.

Based on these results, it seems unlikely (but not impossible) that Parenago's Discontinuity for the Hipparcos sample of main sequence stars over a diameter of about 500 light years (Fig. 4A) can be explained by Spiral Arms. And Spiral Arms seems completely inadequate to account for

Parenago's Discontinuity if the Hipparcos sample of giant stars (Fig. 4B) over a much greater diameter.

But there is a second, perhaps more significant objection to the Spiral Arms hypothesis. For Spiral Arms to be correct, there must be a color difference between stars near the lagging and leading edges of spiral arms in galaxies similar to our Milky Way. Foyle et al. (2011) conducted an extensive spectroscopic study of 12 nearby spiral galaxies. No such color difference was observed.

How a Minded Star Might Alter its Galactic Trajectory

During the preparation of Matloff (2012), I considered methods that a minded star might use to alter its galactic revolution velocity. One conceptual approach is non-isotropic radiation pressure. A stable star maintains itself on the main sequence by an elaborate balancing act. Self-gravitation, which tries to cause the star's collapse, is exactly balanced by the pressure of radiation generated in the stellar interior by thermonuclear fusion. Because stars are spherical in shape, the field of emitted electromagnetic radiation is spherically symmetrical.

But must this necessarily always be the case? Although non-isotropic stellar radiation pressure has never been observed it perhaps cannot be ruled out. If a planetary system is inhabited by a highly advanced technological civilization, a partial shell constructed around the star could be used to alter the star's galactic trajectory (Forgan, 2013). Although such megastructures may indeed exist around some stars, it does not seem likely that every cool star in the sample used to prepare Fig. 4A is attended by one.

A much more likely possibility is a unidirectional or unipolar stellar material jet. Most stellar jets (Fig. 6) are bipolar and I was not aware of unipolar jets during the preparation of Matloff (2012). However, they have been observed in young stars (Namouni, 2007).

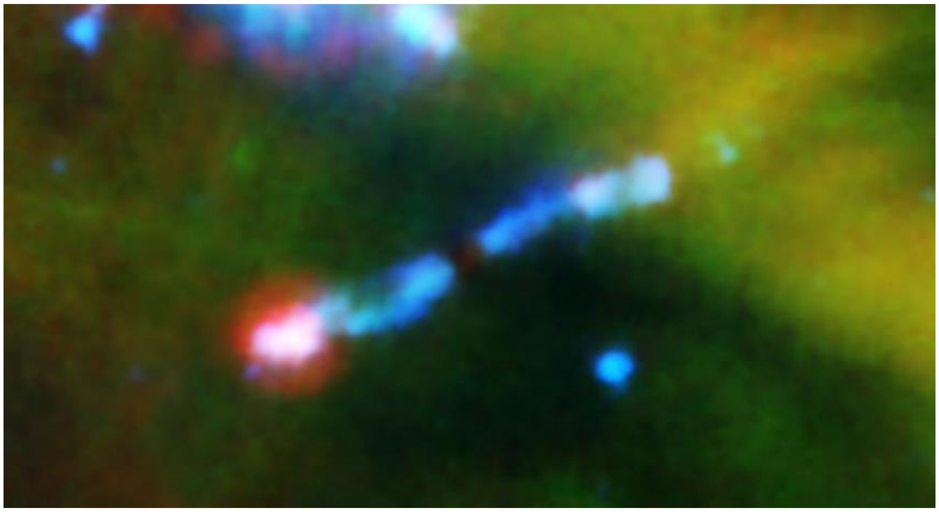


Fig. 6. A Jet of Material Emitted by a Young Star (courtesy NASA).

Consider the case presented in Matloff (2012 and 2015). A young star ejects a unipolar jet for the first billion years of its life. If 20% of the star's mass is ejected at an average jet velocity of 100 km/s, application of Conservation of Linear Momentum reveals that the star's velocity will be altered by 20 km/s. This is the typical difference in galactic revolution velocity between hot stars without molecules and cooler stars with molecules, in Fig. 4A. Incidentally, the mass ejection rate considered here is consistent with that of young stars in the T Tauri phase (Gomez-de Castro et al. 2003).

There is a third, more controversial possibility: telekinesis or psychokinesis (PK). This is, as defined by Dr. Eric Davis in the Foreword to Matloff (2015), the movement of stationary objects by will or intention and without the application known physical forces. No attempt will be made here to delve into the controversy surrounding PK, decades after the famous controversy involving Uri Geller and James "The Amazing" Randi. One excellent source on Cold-War vintage attempts to investigate PK, authored by an MIT physics professor, is Kaiser (2011).

Decades after the CIA-sponsored efforts to study PK and other extrasensory phenomena, opinion on the existence or non-existence of these effects is still very sharply divided. As suggested by Kaiser (2011), Matloff (2015), Eric Davis in the Foreword to Matloff (2015), and by others, it might be time to reopen the case for scientific investigation of these phenomena.

For the sake of argument, let's consider that a weak PK force can be accessed by conscious beings. If a minded star wishes to alter its galactic velocity using PK by 100 km/s (10^7 cm/s) during a billion (10^9) year time interval, this is equivalent to a long-lived human altering her velocity by about 1 cm/s during her century-duration lifespan. It may not even be possible to detect such a weak PK force, if it exists.

Conclusions: Panpsychism as a Subdivision of Observational Astrophysics

If the doctrine of a conscious universe—panpsychism—is to emerge from the realm of philosophy into science, predictions must be made that can be used to verify or falsify the hypothesis using future observation or experiments. A consideration of some of these follows.

Is Parenago's Discontinuity a Galactic or Universal Phenomenon?

As described in Matloff (2015), the European Space Agency has successfully launched and positioned Gaia, a more capable successor to the Hipparcos space observatory. Launched in December 2013 and now located at a gravitationally stable position in the Earth-Sun system, Gaia is embarked on a 5 year mission to accurately measure positions and locations of ~ 1 billion stars in the Milky Way galaxy.

If it turns out the Parenago's Discontinuity is a galaxy-wide phenomenon as hinted at by the Hipparcos results used to prepare Fig. 4B, local alternative explanations such as Spiral Arms will be completely inadequate. As discussed in Matloff (2015a), developing a purely materialistic theory for a galaxy-wide Parenago Discontinuity will be challenging. The next observational step will be space or terrestrial telescopes capable of searching for this phenomenon in other galaxies.

(2) Further Study of Unipolar Stellar Jets

To support or refute the Volitional-Star, Self-Organizing Universe hypothesis, further observational data regarding unipolar stellar jets are required. Is there a correlation between a young star's distance from the galactic center and the jet's intensity and/or direction? What is the duration of these jets during a star's lifetime? It is interesting to note that a portion of the particulate flow from even our mature Sun is directional (Opher et al., 2015).

(3) Does Further Research Support the Conclusion that Molecules are Found in Stars Cooler than F8?

In doing this research, I was struck by the very small stellar sample, as presented in Table 2 and Fig. 3, indicating that the spectral signature of molecules is absent for stars hotter than about F8. To my knowledge, this conclusion is based upon observational data from the 1930's.

Lots of stellar spectra have been observed in recent decades by a host of space observatories. It is hoped that experts in the field of stellar spectroscopy will update humanity's knowledge regarding the onset of stellar molecular spectra.

(*4) Might There be Observational Signs of Panpsychism or Self-Organization at Higher Cosmic Levels?*

Essentially, the work presented here elaborates upon Dyson (1988) and points to the possibility of mind or self-organization operating at the stellar level. But is there any observational evidence for its existence at the galactic level?

A colleague, Ari Maller (2007) has investigated the phenomenon commonly referred to as "galactic cannibalism". Spiral galaxies such as our Milky Way routinely absorb smaller dwarf galaxies. Maller wonders how spiral galaxies maintain their symmetrical shapes after such repeated gouging episodes. Further work along these lines may support (or refute) the concept of self-organization at the galactic level.

Regardless of the outcome of the observational research proposed above, one thing seems clear. The fact that we can propose a "toy model" to support the hypothesis of panpsychism, locate observational evidence and propose observational tests to validate or refute the model indicates that panpsychism may indeed be emerging as a scientific discipline.

Because of space limitations, this essay is concerned mainly with the scientific aspects of panpsychism. To review a fraction of the mythological, poetical, fictional, artistic and philosophical treatments of this topic, consult Matloff (2015).

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