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Stellar Consciousness: Can Panpsychism Emerge as an Observational Science?

In 2011, I was invited to participate in a symposium at the London headquarters of the British Interplanetary Society (BIS). The subject of this one-day event was the contributions of Olaf Stapledon, a British science-fiction author and philosopher. Stapledon's short masterwork, the 1937-vintage Star Maker is widely cited by scientists and engineers because of his scientific and technological predictions.

I am trained in astronomy, astronautics, and planetary science, but one of my early mentors was Evan Harris Walker, a physicist who is regarded by many to be the founder of the modern science of consciousness research. He was the first to propose a theory of the nature of consciousness tied to quantum mechanics and based on quantitative physical and neurophysiological data.

So instead of lecturing about Stapledon's predictive contributions to astronautics, astronomy, genetic engineering, etc., I decided to examine Stapledon's core metaphysics. Is there any scientific evidence to support Stapleton's opinion that the entire universe is in some sense conscious, and a portion of stellar motion is volitional? Could stars be conscious?

Philosophers have long debated the nature of this elusive quantity, but they have largely failed to even find a definition for consciousness. Most philosophers who have addressed the "hard problem" of consciousness reside in two schools of thought. Those who favor epiphenomenalism are generally of the opinion that consciousness is an emergent property of brain function: it arises in brains when neural networks become sufficiently complex. A competing approach is that of panpsychism: those favoring this view suspect that a field of consciousness (or proto-consciousness) permeates the universe and all matter is, to a certain extent, conscious.

To begin my research effort in preparation for the Stapledon symposium, it was first necessary to consider some means that a universal proto-consciousness field could interact with a star. Whatever goes on in the stellar interior, we can be pretty sure that stars do not have neurons. This would seem to rule out Walker's (1970) theory that conscious thought results from elementary particle wave functions tunneling through the electrical potential well between synapses. Stars certainly do not have microtubules, a component of organic cells suggested by Lynn Margolis (2001) and Roger Penrose/Stuart Hameroff (2014) to be the seat of consciousness. But some stars are cool enough to have stable molecules in their outer layers. Bernard Haisch (2006) speculates that the interaction of vacuum fluctuations with molecular bonds—the so-called "Casimir Effect"—is an explanation for how a universal proto-consciousness field interacts with matter. Could consciousness enter matter through the Casimir Effect?

For Stapledon's concept that stellar volition contributes to stellar motions to have scientific validity, and a Casimir-molecular basis of consciousness to be reasonable, there must be some observable difference in kinematics between molecule-free stars and those with molecules in their outer layers. From spectroscopic observations performed in the 1930s, the spectral signature of simple molecules (CH and CN) is absent in stars slightly hotter than the Sun (in star spectral classes hotter than F8). Hotter stars have atoms in their upper layers. All stars have plasma (ions) in their interior.

Stellar Classification

Fully expecting to find no support for Stapledon's metaphysics, I began to investigate observational studies of stellar kinematics. Much to my surprise, I soon uncovered "Parenago's Discontinuity," which is named after Pavel Parenago, a prominent Soviet-era Russian astronomer.

As well as being a very competent astronomer, Parenago was a very wise person. He must have realized that his stellar observations might cut against the grain of Soviet Materialism and result in a long vacation in a very cold and desolate place. So he successfully protected himself by dedicating a mathematical monograph to the most highly evolved human of all time—a fellow named Joseph Stalin!

Parenago had discovered that cooler, less massive, redder stars in our stellar neighborhood revolve around the center of the Milky Way galaxy a bit faster than their hotter, more massive and bluer colleagues. I decided to check this result and soon found some very authoritative sources corroborating Parenago's claim.

Parenago's Discontinuity in Local Dwarf and Giant Stars

In preparing my paper for the Stapledon Symposium, I decided

The Stellar Community

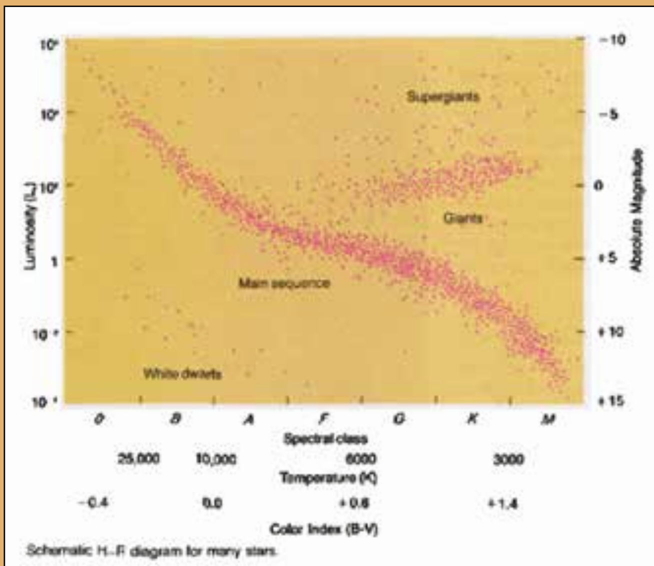


Figure 1. The Hertzsprung-Russell Diagram. A NASA rendering of a familiar star classification scheme, the Hertzsprung-Russell (H-R) Diagram.

Note that the left vertical axis presents star luminous output relative to the Sun. The dimmest stars on this diagram emit about 1/10,000 as much light as the Sun. The brightest, near the top, emit as much light as a million Suns. The horizontal axis presents the stellar spectral classes.

Stars are hot beings. The hottest O stars have surface temperatures of about 30,000 degrees Kelvin (K). The coolest M stars have surface temperatures less than 3,000 degrees Kelvin. For comparison, you will experience a temperature of about 300 degrees Kelvin during a comfortable day on Earth.

Note also that the spectral classes are subdivided. The hottest F stars, for example, are classified as F0 stars. The coolest are F9. The (B-V) color indices quantitatively presents the fact that hot, O stars are bluer than cool red stars. The (B-V) color index increases as stars get redder and cooler.

The luminosity classes are also presented on the H-R Diagram. The major luminosity classes are Main Sequence Dwarfs, Giants, Supergiants, and White Dwarfs. Most stars in the sky, including our Sun, emit energy by converting hydrogen to helium and reside on the Main Sequence. Our Sun is classified as a G0 dwarf and is about half-way through its 10-billion-year residence on the Main Sequence. After it exhausts much of its internal hydrogen, it will swell to become a luminous Giant. After "only" another 100 million years or so, it will cross the Main Sequence once again to end its life as a hot, sub-luminous White Dwarf.

Stellar life expectancy on the Main Sequence has a lot to do spectral class and mass. Large, massive O-type stars only live on the Main Sequence for a few million years. The cool, less massive M-stars reside on the Main Sequence for a trillion years or longer.1

to check recent publications on the kinematics of main sequence dwarf stars in our galactic vicinity.2 The data come from two sources. The Binney et al. (1997) data points in Figure 2A are from observations of about 6,000 main sequence dwarf stars out to ~260 light years by the European Space Agency (ESA) Hipparcos space observatory. The Gilmore and Zelik (2000) data points are from the 2000 edition of Allen's Astrophysical Quantities, perhaps the most authoritative publication in the field of astrophysics.

The velocity discontinuity in Fig. 2A is very sharp for both data sets at (B-V) = 0.45-0.50. This correspond closely to the (B-V) color index of F8 stars. The molecular signatures appear in stars of F8 spectral class and cooler (Matloff, 2011, 2016).

Figure 2B is based on Hipparcos data from thousands of giant stars out to >1,000 light years (Branham, 2011).3 Although, as Branham discusses, Parenago's velocity discontinuity is evident in this figure, it is not as sharp as in Figure 2A. That is probably because stellar distance estimates are less accurate for more distant stars and comparison with the reference frame (called the Local Standard of Rest) is less accurate for a larger-diameter sample.

The European Space Agency Gaia space observatory, a successor to Hipparcos, is now on station. The purpose of this spacecraft is to determine positions and motions of ~1 billion stars in the Milky Way galaxy (Matloff, 2012, 2015, 2016). But Gaia final results will not be processed and released for a few years. So I have performed a search for other observational results relating to Parenago's Discontinuity. Francis and Anderson (2009) have demonstrated the existence of this phenomenon in their analysis of 20,574 stars out to about 1,000 light years.

Using a terrestrial 4-meter Schmidt telescope with a 5-degree field of view, Tian et. el (2015) have evaluated the kinematics of about 200,000 F, G, and K stars with heliocentric distances between about 300 and 3,000 light years. Although the error bars seem higher than in the Hipparcos data set, cooler stars with molecules in their upper layers do seem to move more rapidly around the galactic center than hot stars.

Explanations for Parenago's Discontinuity

Scientists develop competing hypotheses to explain various physical phenomena. The concepts that best succeed in explaining experimental or observational evidence evolve into successful theories. Here are some of the competing hypotheses proposed to explain Parenago's Discontinuity.

One possibility, discussed by Bochanski (2008), relate to the fact that all stars begin their lives within dense gas- and dust-filled birth nebulae.

The density of stars within these comparatively short-lived galactic structures is much larger than within most of the galaxy. Consequently, low-mass stars might be ejected at higher velocities from the birth nebulae by gravitational interactions with other stars than more massive stars. This would certainly result in a higher dispersion in the galactic velocities of a star sample, but it does not explain the systematic velocity

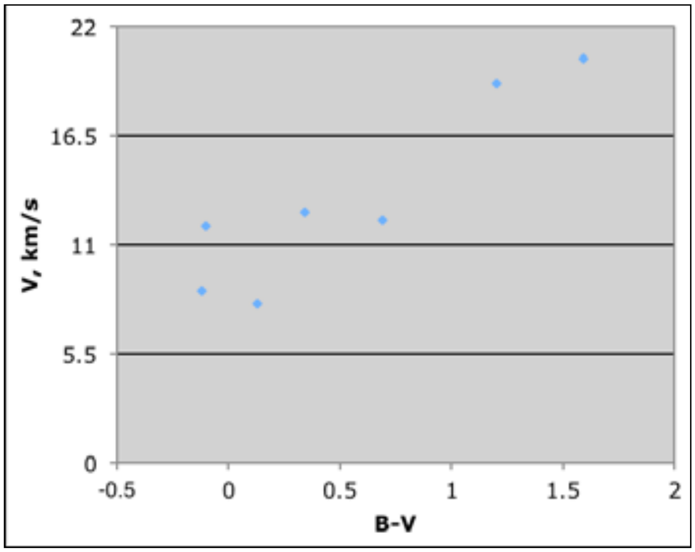


Fig. 2.(A) Parenago's Discontinuity for Main Sequence Stars out to ~260 Light Years. Diamond Data Points are from Gilmore & Zelik (2000). Square Data Points are from Hipparcos Space Observatory Data (Binney et al, 1997).

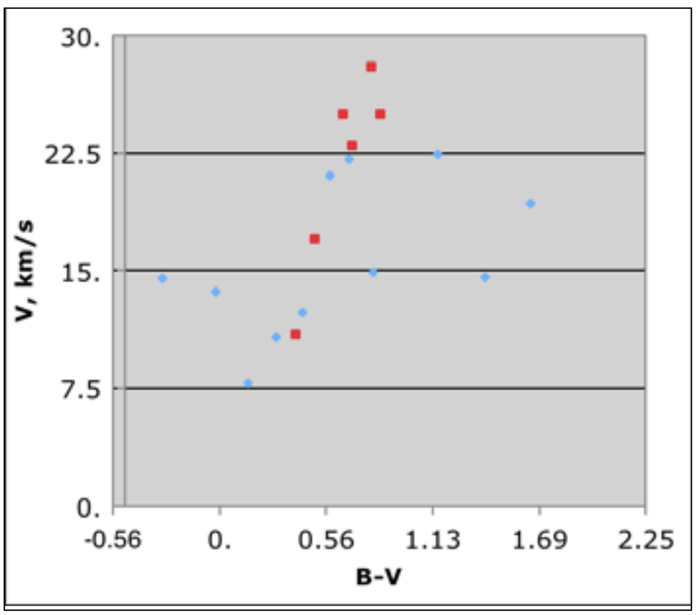


Fig. 2. (B) Parenago's Discontinuity for Giant Stars out to >1,000 Light Years (Branham, 2011).

difference along the direction of stellar galactic revolution.

A second hypothesis, called Spiral Arms Density Waves, is based upon the fact that dense, diffuse nebula are generally located in the spiral arms of galaxies like our Milky Way (Binney, 2001 and DeSimone, 2004). Consider a nebula with a gas density significantly greater than that of the surrounding interstellar medium. As it drifts through a star field, it might drag along low-mass stars at a higher velocity than high-mass stars.

A problem for advocates of the Spiral Arms hypothesis is the comparative paucity of large diffuse nebula within the present day Milky Way galaxy. I have searched three major compilations of deep-sky objects (Matloff, 2016). Nebula within the present-day Milky Way are too small to affect star motions over a ~500 light-year diameter star sample, such as the one used to prepare Fig. 2A.

But what about the past? Francis and Anderson (2009) suggest that billions of years in the past, characteristics of the Milky Way galaxy may have been different and Parenago's Discontinuity may be caused by streams of old stars. This seems unlikely based upon an estimate of local solar-type main sequence dwarf stars by Mamajek and Hillenbrand (2008). According to their study of 100 stars out to about 50 light years, 15% of the local dwarfs are aged less than 1 billion years, 16% are aged 1-2 billion years, 12% are aged 2-3 billion years, 8% are aged 3-4 billion years, and 14% are aged 4-5 billion years. Only a minority of the stars in their sample are older than the Sun (4.7 billion years). Local main sequence stars certainly do not come from the same birth nebula. And the vast age differences among stars in this local sample seems to argue against the Francis and Anderson (2009) conjecture.

There is a second, perhaps more significant objection to Spiral Arms. For this hypothesis to be correct, there must be a color difference between stars near the leading and lagging edges of the spiral arms of galaxies like our Milky Way. According to an observational study of 12 nearby spiral galaxies by Foyle et al. (2011), no such color difference has been observed.

The hypothesis I propose evokes panpsychism and galactic self-organization: that consciousness emerges in molecules through an interaction with a universal proto-consciousness field that is congruent or identical with vacuum fluctuations. Stars cool enough to possess upper layers with stable molecules are more conscious than hotter stars and move differently to participate in galactic self-organization.

How Minded Stars Might Adjust Their Galactic Trajectories

There are at least three ways that a minded, molecule-rich star might adjust its galactic trajectory.

The first possibility is differential electromagnetic radiation pressure. Although photons have no mass, they do have momentum. This means that if a star emitted more of its light in one direction, it would accelerate (in accordance with Newton's Third Law) in the opposite direction. However, observations confirm that the luminous emission from all stars (including our Sun) appears to be isotropic—the same in all directions. It might be of interest to situate a number of in-space solar observatories to check whether there is a preferred direction to solar luminous emissions, from the viewpoint of an observer near the galaxy's center.

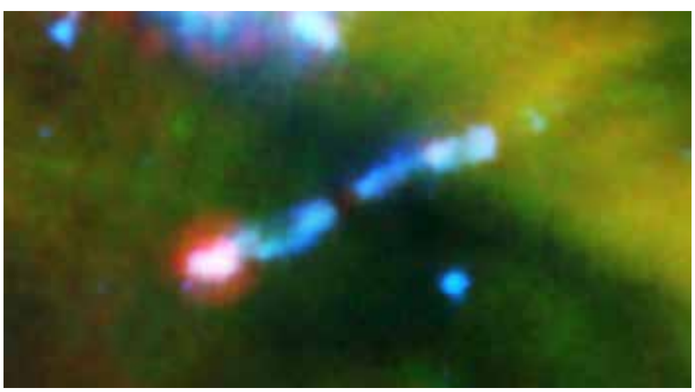
A second, more likely possibility, is unipolar jets emitted from young stars. Many infant stars have been observed to emit jets of material (Fig. 4). During the preparation of Matloff (2012), I was of the opinion that stellar jets tend to be bipolar—with equal jet speed and material outflow in both directions. But unipolar jets have from young stars have also been observed (Namouni, 2007).

Consider, for example, a young star that emits 20% of its mass in the first billion years of its main sequence life in a unipolar jet with an average jet velocity of 100 kilometers per second (Matloff 2012, 2015, 2016). If the jet is situated along the direction of the star's motion around the galactic center, the star's velocity in this direction will change by 20 kilometers per second, enough to account for Parenago's Discontinuity in Fig. 2A.

But there is a third, somewhat more controversial alternative: a very weak psychokinetic (PK) force. Because of my friendship with Evan Harris Walker, I had a ringside seat to the infamous controversy between The Amazing Randi and Uri Geller regarding the veracity of experimental PK data. Although I have been privileged to know people on both sides of this controversy, I have nothing new to add to it. [4]

It is easy to estimate how strong a PK force must be to alter a star's circumgalactic velocity by 20 kilometers per second in a billion years. On a more human scale, this is equivalent to a long-lived female runner altering her velocity by 0.2 centimeters per second in a century-long lifespan. I wonder if we could even measure the weak PK force required to accomplish this deed.

I have published two entries on this topic on Centauri-Dreams, a blog moderated by science-journalist Paul Glister. It is interesting to note the passionate responses supporting both sides of the Geller/Randi controversy, decades after the events took place. Hopefully, experimental scientists can move beyond this and conduct experiments to determine whether PK is a physical phenomenon or a magician's illusion.



A Young Star Emitting a Jet of Material (courtesy NASA).

Is Panpsychism Emerging as an Observational Science?

In order for a discipline to emerge from metaphysics to become a science, it must satisfy a number of requirements. Evidence must exist, predictions based on the concept must be in place to verify or falsify it, there should be multiple workers in the field, and it must be quantifiable. Does panpsychism as applied to the stellar and galactic universe satisfy these criteria?

The Evidence

First let's look at the quality of the evidence and how to improve it. A literature search will reveal that the apparent onset of molecular spectral signatures in the upper layers of F8 stars is based upon observations of only a few dozen stars during the 1930s (Matloff, 2016). With all the modern infrared stellar spectral observations by a host of space observatories, it would be very nice if some enterprising specialist in infrared astronomy could check the onset of molecular spectral signatures using observations of many stars.

But there is additional evidence supporting the existence of self-organization at the stellar and galactic levels. Spiral galaxies such as our Milky Way routinely absorb smaller dwarf galaxies in a process referred to as "galactic cannibalism." Ari Maller (2007) wonders how galaxies maintain their spiral shapes after such large "meals."

Predictions

Now I will present a few predictions that will serve to verify or falsify the Volitional Star Hypothesis as a panpsychic explanation for Parenago's Discontinuity:

(1) Observations from the ESA GAIA spacecraft will confirm that Parenago's Discontinuity is a galactic, non-local phenomenon.

(2) There will be a correlation between stellar jet direction/intensity and a star's distance from the galactic center. And as a replacement or adjunct to Prediction (2), some form of weak PK will be verified in replicable experiments.

(3) Spectral study of many more spiral galaxies will not reverse the negative results so far regarding the Spiral Arms hypothesis.

(4) Very advanced computers using molecule-sized components will display aspects of consciousness.

Other Researchers in the Field of Astro-Panpsychism

I am neither the first nor only serious scientist to address the possibility that consciousness pervades the universe. In his classic work on universal self-organization, Erich Jantsch (1980) proposes that the upper layers of stars (where stable molecules will be found) might be conscious.

The renowned British mathematical physicist Sir Roger Penrose, in collaboration with the American anesthesiologist Stuart Hameroff, have developed, as mentioned above, a theory of consciousness that has received some experimental support. They speculate (Penrose and Hameroff, 2001) that neutron stars may be conscious. It may be totally coincidental, but a team led by D. K. Berry (2016) has recently published a paper denoting a fascinating similarity between biological cellular structures and simulated structures in neutron stars.

Writing in a published monograph and a recent issue of the peer-reviewed Acta Astronautica, Clement Vidal (2014, 2016), a philosopher on the faculty of the Free University of Brussels, has investigated certain classes of binary stars from a biological perspective. He concludes that these stellar associations satisfy many of the criteria of living organisms.

Clearly, only a few intrepid researchers have thus far investigated the possibility that aspects of panpsychism can be observed in the universe. As the field matures, there will doubtless be others.

Quantification of Panpsychism

During August 2016, I participated in a workshop related to Yuri Milner's Breakthrough Initiative Project Starshot, at NASA Ames Research Center on Palo Alto California. One of the participants was Greg Benford, a physicist/science-fiction author who has considered panpsychism in several of his novels. During our discussion, Greg mentioned that a problem with scientific panpsychism is that quantification has not been attempted. And quantification is a requirement for panpsychism to emerge as a science.

This difficulty has been addressed by Giulio Tononi (2012a, 2012b), a professor of psychiatry who holds the Chair of Consciousness Science at the University of Wisconsin. Tononi's approach, Integrated Information Theory, is a quantitative approach that treats consciousness as an intrinsic property of any physical system. Consciousness in any system is structured. Its level depends on the level of interconnections allowing the integration of information. A molecule, with a small number of interconnection possibilities, is calculated to have a low consciousness level. A human brain with billions of neurons has a much higher level.

Panpsychism as a Science

Panpsychism may not yet be at the point at which it can be accepted as a mainstream science. But since it satisfies the above requirements, it certainly can be accepted as a speculative scientific alternative to explain many phenomena on the human and cosmic levels.

I'm glad I have been able to contribute in a small way to the effort to elevate this philosophical debate to the realm of observational science.

Acknowledgements

This paper could not have been written without my participation in activities of YHouse, a New York City non-profit engaged in the exploration of awareness and consciousness. In particular, I have been inspired by three astrophysicists associated with YHouse: Piet Hut, Caleb Scharf, and Ed Turner. George Musser, also a YHouse participant, provided information on Giulio Tononi's Integrated Information Theory. I thank Olga Ast, who after attending a YHouse function, emailed a description of D. K. Berry et al.'s recent publication.

ENDNOTES

1 A lot more information regarding the H-R Diagram can be obtained from any college-level astronomy text, such as Chaisson/McMillan (2008).

2 As well as being included in the presentation version [which was kindly delivered by Kelvin Long, who at the time was editor of The Journal of the British Interplanetary Society (JBIS)], it was included in my first peer-reviewed publication on this topic (Matloff, 2012).

3 Details of data reduction to prepare this figure are presented in Matloff (2015).

4 An excellent reference regarding the Geller/Randi affair was authored by an MIT physics professor (Kaiser, 2011).

REFERENCES

Berry, D. K., Caplan, M. E., Horowitz, C. J., Huber, G., and Schneider, A. S., 2016. "Parking Garage" Structures in Nuclear Astrophysics and Cellular Biophysics," Physical Review C, 94, 055801.

Bochanski Jr., J. J. (2008). M Dwarfs in the Local Milky Way: The Field Low-Mass and Stellar Luminosity and Mass Functions. Ph.D. Thesis, University of Washington, Dept. of Astronomy.

Binney, J. J., Dehnen, W., Houk, N., Murray, C. A., Preston, M. J. 1997). "Kinematics of Main Sequence Stars from Hipparcos Data," in Proceedings ESA Symposium Hipparcos Venice 97, ESA SP-402, Venice, Italy, May 13-16, 1997, 473-477. Paris, European Space Agency.

Binney, J. J. 2001, "Secular Evolution of the Galactic Disk," in Galaxy Disks and Disk Galaxies, eds. F. Bertoli and G. Coyne, ASP Conference Series vol. 230. San Francisco, Astronomical Society of the Pacific.

Branham, R. L. 2011. "The Kinematics and Velocity Distribution of the GIII stars," Revisita Mexicana de Astronomia y Astrofisica, 47, 197-209.

Chaisson, E. and McMillan, S. 2008. Astronomy Today, 6th ed. San Francisco, CA: Pearson/Addison-Wesley.

DeSimone, R. S., Wu, X., Tremaine S. 2004. "The Stellar Velocity Distribution in the Stellar Neighborhood," Monthly Notices of the Royal Astronomical Society, 350, 627-643.

Foyle, K., Rix, H.-W., Dobbs, C., Leroy, A., Walter, F. 2011. "Observational Evidence Against Long-Lived Spiral Arms in Galaxies," Astrophysical Journal, 735, Issue 2, Article ID = 101 (2011).

Francis, C. and Anderson, E. 2009. "Calculation of the Local Standard of Rest from 20,574 Local Stars in the New Hipparcos Reduction with Known Radial Velocities," New Astronomy,14, 615-629.

Gilmore, G. and Zelik, M. 2000. "Star Populations and the Solar Neighborhood," Chap. 19 in Allen's Astrophysical Quantities, 4th ed., ed. A. N. Cox, New York, Springer.

Haisch, B. 2006. The God Theory: Universes, Zero-Point Fields and What's Behind It All. San Francisco, CA, Weiser Books.

Hameroff, S. and Penrose, R. 2014. "Consciousness in the Universe: A Review of the 'Orch OR' Theory," Physics of Life Reviews 11: 39-78.

Jantsch. E. 1980. The Self-Organizing Universe: Scientific and Human Implications for the Emerging Paradigm of Evolution, New York: Pergamon.

Kaiser, D. 2001. How the Hippies Saved Physics. New York: Norton.

Maller, A., 2007. "Halo Mergers, Galaxy Mergers, and Why Hubble Type Depends on Mass," presented at Formation and Evolution of Galaxy Disks, Vatican Observatory, Rome, October 1-5, 2007.

Mamajek, E. E. and Hillenbrand, L. A., 2008. "Improved Age Estimation for Solar-Type Dwarfs Using Activity-Rotation Diagnostics," arXiv:0807.1686v1 [astro-ph] 10 Jul 2008.

Margolis, L. 2001. "The Conscious Cell. Cajal and Consciousness," Annals of the New York Academy of Sciences 929: 55-70.

Matloff, G. L. 2012. "Olaf Stapledon and Conscious Stars: Philosophy or Science?" JBIS 65, 5-6.

Matloff, G. L. 2015. Starlight, Starbright?: Are Stars Conscious?. Norwich. UK: Curtis Press.

Matloff, G. L. 2016. "Can Panpsychism Become and Observational Science?" Journal of Consciousness Exploration and Research, 7, 524-543.

Namouni, F. 2007. "On the Flaring of Jet-Sustaining Accretion Disks," Astrophysical Journal, 659, 1505-1510.

Penrose, R, and Hameroff, S. 2001. "Consciousness in the Universe: Neuroscience, Quantum Space-Time Geometry and the Orch OR Theory," Journal of Cosmology, 14 (http://journalofcosmology.com/Consciousness160.html)

Tian, H.-J., Liu, C, Carlin, J., Zhao, Y-H, Chen, X-L, Wu, Y, Li, G-W, Hou, Y-H, Zhang, Y. 2015. "The Stellar Kinematics in the Stellar Neighborhood from Lamost Data," arXiv:1507.05624v1 [astro-ph.GA] 20 Jul 2015.

Tononi, G. 2012a. "Integrated Information Theory of Consciousness," Archives Italiennes de Biologie, 150, 290-326.

Tononi, G. 2012b. PHI: A Voyage from the Brain to the Soul. New York: Pantheon.

Vidal, C. 2014. The Beginning and the End: The Meaning of Life in a Cosmological Perspective. New York: Springer.

Vidal, C. 2016. "Stellivore Extraterrestrials: Binary Stars as Living Systems," Acta Astronautica,128, 251-256.

Walker, E. H. 1970. "The Nature of Consciousness," Mathematical Biosciences 7: 131-178.

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