Article

Shifting Paradigms

Gregory L. Matloff[1]* and Roman Ya. Kezerashvili[1,2]

[1]Physics Department, New York City College of Technology, The City University of New York, Brooklyn, NY, USA
[2]The Graduate School and University Center, The City University of New York, New York, NY, USA

Abstract

A scientific paradigm is defined as a framework of basic assumptions, methodology and ways of thinking that is commonly accepted by members of a scientific discipline. One such paradigm is the assumption that astrophysical processes can be explained by purely materialistic concepts without the need to invoke consciousness. A peer-reviewed analysis of observational data obtained by the Gaia space observatory reveals that stars in our galactic vicinity are generally much older than the Sun and that stars accelerate as they age along their trajectories of galactic revolution. The authors have recently published an investigation of possible physical mechanisms of stellar acceleration. If future research validates the stellar acceleration result, the astrophysical paradigm might shift to include the possibilities of a sentient, self-organizing Universe or the activities of a hyper-advanced galaxy-wide civilization.

Keywords: Astrophysical paradigm, anomalous stellar acceleration, self-organizing Universe, galaxy-wide extraterrestrial civilization. panpsychism, Parenago's Discontinuity.

1. Introduction

According to Kuhn (1970), science experiences long periods when the existing approach to problem-solving predominates. A scientific revolution occurs when the prevailing mindset no longer applies. During a scientific revolution, the paradigm, which is the framework of basic assumptions, methodology and modes of thinking commonly accepted by members of a scientific discipline no longer applies. Paradigms must be considered as properties of collective human consciousness.

One common example of a scientific paradigm shift is the replacement of Aristotle's physics by Newtonian mechanics in the 17th century. Another is the incorporation of Newton's gravity theory into Einstein's general relativity in the early 20th century.

Most contemporary mainstream astrophysicists subscribe to a purely materialistic conception of the Universe: motions and properties of celestial objects can be explained without resorting to conscious or volitional properties. Purely physical properties such as particulate matter and fields associated with four basic forces are sufficient.

*Correspondence: Gregory L. Matloff, Physics Department New York City College of Technology, CUNY, Brooklyn, NY, USA E-mail: GMatloff@citytech.cuny.edu

It must be noted that even among physicists, the current materialistic paradigm has not been universally accepted. The apparent role of consciousness in quantum mechanics has been amply discussed in the literature (Kafatos & Nadeau,1990; Rosenblum & Kuttner, 2006).

Among exceptional physicists not accepting the materialistic paradigm was Albert Einstein, who pioneered both quantum mechanics and relativity theory. Einstein is quoted as believing in Spinoza's God—a being who is revealed in the lawful harmony of the universe—rather than the God of conventional religion who is concerned with the activities and fates of humans (Calprice, 2011).

Another who critiqued the mainstream paradigm was Erwin Schrodinger, a founder of quantum theory. As well as expressing his belief in Spinoza's pantheism and noting the link between mind and matter, Schrodinger expressed the belief that all living beings are aspects of one being—the apparent existence of multiple selves is illusory (Schrodinger, 1964).

More recently, Spinoza's pantheism—the metaphysical assumption that deity permeates the Universe—has been largely superseded by panpsychism—the metaphysical assumption that a field of consciousness or proto-consciousness permeates the Universe (Chalmers, 2015; Nagel, 2012).

Astrophysicist Erich Jantsch (1980) has investigated the possibility that the Universe self-organizes at all levels. If confirmed, universal self-organization would strengthen the case for panpsychism. At least one noted contemporary physicist is convinced that Mind acts at multiple levels in the Universe (Dyson, 1988). Some have begun the investigation of quantitative processes that might transfer panpsychism from metaphysics to physics (Tononi, 2012a; 2012b).

The concept of stellar sentience, a "symptom" of panpsychism and universe self-organization, predates the emergence of pantheism in classical Greece (Matloff & Bangs, 2015). Perhaps the first modern scholar of note to seriously consider this concept was Gustav Fechner (1801-1897), the founder of psychophysics (Marshall, 1969).

One scholar who was likely influenced by Fechner was the visionary British science-fiction-author/philosopher Olaf Stapledon. Stapledon's 1937 masterwork *Star Maker* is widely cited by astronomers and astronautical scientists. Participating in a Stapledon symposium at the London headquarters of the British Interplanetary Society, Gregory Matloff (2012) investigated the scientific evidence for Stapleton's core metaphysics—that the universe is in some sense conscious and a portion of stellar motion is volitional.

Stellar consciousness cannot be neuron-based (Walker, 1970) or microtubule-based (Hameroff & Penrose, 2014) since these objects cannot exist in even the coolest stars. But cooler stars have simple molecules in their outer layers and one consciousness theory predicts that consciousness interacts with molecular matter through quantum fluctuations (Haisch, 2006).

In preparing Matloff (2012), a literature search was conducted to determine if the kinematics of cool stars with molecules differs from the kinematics of hotter stars. It was learned that Pavel Parenago (1950) reported that cool stars revolve around the galactic center a bit more rapidly

than hotter stars. This phenomenon was named as Parengo's Discontinuity. Parengo's Discontinuity has been confirmed by other observers (Roman, 1950).

More recent data from the European Hipparcus astrometric space telescope has been used to demonstrate that Parenago's Discontinuity is clearly apparent in a sample of more than 6,000 main sequence stars within ~260 light years of the Sun and the discontinuity is at or very near the point in the stellar population where molecule signatures become apparent in stellar spectra (Matloff, 2012; 2015; 2016).

Although the Hipparcus data is supportive of the stellar volition hypothesis, it is not conclusive. A materialistic explanation for Parenago's Discontinuity was Spiral Arms Density Waves (Binney, 2001; DeSimmone et al., 2004). According to Density Waves, diffuse galactic nebulae occasionally pass through the Sun's stellar neighborhood. Because these stellar nurseries are considerably denser than the surrounding inter-cloud interstellar medium, they can drag low-mass stars along faster than more massive stars.

As reported by Matloff (2016), three atlases of deep-sky objects were consulted to determine the largest size of known diffuse nebulae. Only one, the Taruntula Nebula (30 Doradus) is larger than ~ 520 light years and could accommodate all the stars in the Hipparcus sample.

It seemed that Density Waves was an unlikely explanation for Parenago's Discontinuity and that this is a non-local phenomenon. But based upon the data available at the time, Density Waves could not be ruled out.

2. Non-Local Parenago Discontinuity and a New Feature

In 2013, the European Space Agency launched Gaia as a more capable successor to the Hipparcus space telescope. As reviewed by Matloff (2020), this spacecraft is currently operational, and its mission is to obtain accurate location and motion data for ~ 1 billion stars in the Milky Way galaxy.

The first data release from Gaia (Gaia DR1), issued in 2016, contained position and motion data for more than 1,260,000 main sequence stars. Using this extensive data set, Vityazev et al. (2018), validated Parenago's Discontinuity for stars >500 light years from the Sun. It therefore seems very likely that Parenago's Discontinuity is a non-local or galactic phenomenon. Because 30 Doradus is not large enough to encompass this volume, Spiral Arms Density Waves is likely not an explanation for Parenago's Discontinuity.

As well as validating the Hipparchus-Based Parenago Discontinuity results, Vityazev et al. (2018) used the large Gaia DR1 data set to demonstrate that stars in the Sun's galactic neighborhood are generally 1-billion year or more older than our Sun. They also analyzed an unexpected bump is Hipparcus and Gaia plots of star galactic revolution velocity vs. star spectral class, which is observed for yellow dwarf stars (like the Sun) and cooler orange dwarfs. Apparently, stars accelerate as they age in the direction of galactic revolution. Their velocity increases by ~1 km/s per billion years that is the acceleration ~ 3×10^{-14} m/s^2. Eight possible

physical causes for this anomalous stellar acceleration have been suggested by Kezerashvili et al. (2021).

The evaluation of these eight physical mechanisms began with an estimate of the force magnitude required to accelerate a Sun-like star by 1 km/s in 1 billion years. It was next determined whether each selected possible cause could supply the required force. Some of the possible stellar acceleration mechanisms evaluated by Kezerashvili et al. (2021) considering in their analysis that all stars are like the Sun, might be considered mechanistic, others are likely due to volitional sentient stars or the activities of advanced space-faring extraterrestrial (ET) civilizations.

Each of the eight physically possible mechanisms of stellar acceleration examined by Kezerashvili et al. (2021) are considered below:

1. Unidirectional or Focused Stellar Electromagnetic Flux. Every star emits copious amounts of electromagnetic energy in an isotropic manner, humans perceive this as light or invisible but detectable electromagnetic waves. But if a sentient or volitional star could focus this energy into a narrow beam, photon pressure could accelerate the star in the opposite direction. Although physically possible, such "jets" are not observed in mature stars and the force produced is a small fraction of the force required to accelerate a Sun-like star by 1 km/s in 1 billion years $\sim 3 \times 10^{-14}$ m/s^2.

2. Stellar Acceleration Due to Galactic Cannibalism. Large spiral galaxies such as our Milky Way periodically increase their mass by absorbing small satellite galaxies at ~ 1 billion years intervals. If stars simply blinked into existence, this mechanistic process might explain the anomalies stellar acceleration because older stars would be more affected by this process than young stars. Unfortunately, stars don't simply blink into existence. Instead, they evolve in diffuse nebulae. The molecules and dust particles comprising these structures would be affected by this "galactic cannibalism" in the same manner as older stars.

3. Stellar Mass Loss Via Thermonuclear Fusion. All mature stars, including our Sun, shine by converting mass into energy deep in the stellar interior, by thermonuclear fusion. Application of the law of angular momentum conservation reveals that the stellar mass loss in this mechanistic stellar acceleration process is too small for Sun-like stars to account for the stellar acceleration value calculated by Vityazev et al. (2018).

4. Non-Isotropic Stellar Wind. As well as emitting lots of radiant energy, our sun ejects a highly variable, high-velocity stream of ionized sub-atomic particles (mostly electrons, protons, and helium nuclei) into the interstellar medium. A sentient star might concentrate this into a unidirectional jet that might accelerate the star in the opposite direction. Although this process is physically possible, ejection of such ionized-particle jets is not observed in mature stars. Even if it occurs, the linear momentum change due to such a process in a Sun-like star is too small to account for the stellar acceleration value $\sim 3 \times 10^{-14}$ m/s^2 calculated by Vityazev et al. (2018).

5. Accelerated Unidirectional Stellar Wind It is not impossible that an advanced space-faring ET civilization might construct a dual-purpose Dyson/Stapledon megastructure around a star (Dyson, 1960). A fraction of the star's radiant output would first be collected. This stellar energy would then be used to accelerate a unidirectional stellar-wind jet emitted by the star. Calculations presented in Kezerashvili et al. (2021) reveal that this alternative could account for the observed stellar acceleration.

6. Coronal Mass Ejections. Periodically, our Sun ejects large quantities of ionized coronal material into the interplanetary medium at velocities as high as ~3,000 km/s. If a sentient star periodically ejected its entire corona in a unidirectional jet, this scenario could possibly account for the anomalous stellar acceleration reported by Vityazev et al. (2018). Although physically possible, this process has not been observed.

7. Unidirectional Neutrino Flux. In addition to producing radiant energy deep within its interior, thermonuclear reactions produce copious amounts of weakly interacted, electrically neutral and negligible mass particles, called neutrinos. About 3% of the Sun's energy output is in the form of neutrinos. A sentient star might be capable of focusing a fraction of these neutrinos into a tight beam. If the equation for photon linear momentum can be applied to neutrinos, it is demonstrated by Kezerashvili et al. (2021) that this process could account for the stellar acceleration reported by Vityazev et al. (2018).

8. Solar-Wind Thermonuclear Fusion. A hyper-advanced, space-faring ET civilization might be capable of converting its star into a spacecraft by reacting protons in the ejected stellar-wind in a thermonuclear reactor and ejecting the energized helium nuclei in a unidirectional jet (Svoronos, 2020). Although the required technology is very far in advance of anything contemporary terrestrial civilization could conceive of, the process is physically possible and could account for the stellar acceleration calculated by Vityazev et al. (2018).

Kezerashvili et al. (2021) note that the eight-physically possible stellar acceleration processes discussed above may be supplemented by other possibilities. But it does seem clear from the discussion above that mechanistic explanations generally do not perform as well as those requiring stellar-sentience / universe self-organization or the activities of a hyper-advanced space-faring ET civilization.

If confirmed by other researchers, the anomalous stellar acceleration reported by Vityazev et al. (2018) might support attempts to alter the current materialistic astrophysical paradigm. The next section considers positive and negative consequences of such a paradigm shift.

3. New Paradigm Choices

If the anomalous stellar acceleration is confirmed and if mechanistic explanations for this phenomenon do not succeed, the current astrophysical materialistic paradigm is in serious trouble. This section considers advantages and disadvantages of two possible replacements.

Sentient Stars: Pros and Cons

If a portion of stellar motion is indeed proven to be volitional, the hypothesis of Universe self-organization or panpsychism will be strengthened. Although a condition for life and consciousness might be the in congruence with pre-historic animism and Classical Greek pantheism. In a sense, science will return to its roots. As is also discussed in the Introduction, such a possibility, although currently rejected by mainstream astrophysics, is favored by many pioneers of contemporary physical theory.

But not all scientists will accept this paradigm shift. One problem is astrology. Anyone who has studied astronomy at even the introductory level is aware that modern astronomy textbooks, without exception, dismiss astrology as a remnant of a pre-scientific past. Its only relevance is that pre-Newtonian astronomers often earned a portion of their income by casting horoscopes, Also, astrology and astronomy have similar or identical ancient roots.

To understand the possible issue with astrology, consider the case of a mature, main sequence star. Energy is produced deep in the stellar interior and is degraded (becomes more disordered) as it rises to the surface. The energy flow passes through the layers near the star's photosphere which, in the case of cooler stars, contains simple molecules. This energy is then emitted to the environment (the interstellar medium) at higher entropy (less organization) then in the stellar interior. Such a self-organizing star satisfies many of the requirements of a dissipative structure (Jantsch, 1975, 1980).

What Jantsch (1975, 1980) could not have known is that all solar system planets and at least some dwarf planets have internal energy sources (Haussmann et al. 2006; Wang, 1990).
Although a condition for life and consciousness might the existence of self-organizing dissipative structures, all such structures might not be conscious to alive. However, Vidal (2014, 2016) has demonstrated that at least one class of binary stars has properties similar to those of living organisms. Penrose and Hameroff (2001) also speculate that at least one class of stars is conscious.

Quantum entanglement plays a major role in the Hameroff and Penrose (2014) theory of consciousness. If planets and stars are conscious and if the conscious activities of celestial bodies can entangle with the brains of humans, celestial bodies could conceivably affect human actions.

This is certainly not the Babylonian, Chinese or Indian astrology currently practiced. But, although perhaps not very likely, it cannot be ruled out. Accepting such a possibility would be a bitter pill for the astrophysics education and research establishments.

Activities of a Hyper-Advanced Extraterrestrial Civilization: Pros and Cons

The alternative paradigm to sentient stars suggested here will also present difficulties to the astrophysics establishment. The arguments for activities of a hyper-advanced extraterrestrial civilization that has spread through the galaxy are very straightforward.

First, Earth-like rocky planets within the habitable zones of stars must be very common. Our Sun's nearest stellar neighbor, Proxima Centauri, is accompanied by one (Anglada-Escude, et al., 2016). Proxima Centauri is about 4.3 light years from the Sun ($\sim 4.3 \times 10^{13}$ km). A number of possible in-space propulsion systems may be feasible that could reach this destination in ~ 1000 years (Long, 2011; Matloff, 2005). Research indicates that human-occupied space habitats could be constructed that might ultimately be capable of interstellar voyaging (O'Neill, 1976).

The second data release from the Gaia space observatory (DR2) has been used to determine that Sun-like stars approach our Sun at distances < 1 light year at intervals of ~ 500,000 years (Bailer-Jones et al., 2018). If the starships we can envision today attempted a stellar crossing during a close stellar encounter, interstellar travel duration might be "only" 2-3 centuries. Close stellar encounters might be considerably more frequent because the Gaia data sets underestimate the number of low luminosity, low-mass red dwarf stars in the solar neighborhood.

If interstellar travel speeds can never exceed those of currently conceivable human-occupied starships and if interstellar expansion occurs only during close stellar encounters to reduce travel duration, a very simple analytical top can be applied to estimate how long it would take a single, long-lived space-faring civilization to occupy the Milky Way galaxy (Matloff, 2019). In this analysis, n is the number of migration generations. At time = 0 years, $n = 1$. At time = 500,000 years, $n = 2$, and at time = 1,000,000 years, $n = 3$. If a migration occurs during each stellar encounter, the number of planetary systems (P) occupied by this hypothetical civilization, can be readily estimated:

$$P \approx 2^n.$$

At the start, $t = 0$ and $n = 1$. At time = 500,000 years, the first migration has occurred resulting in $n = 2$ occupied planetary systems. It is assumed that residents of both of these systems conduct interstellar migrations at time ~ 1,000,000 years. Within 18 million years, all or most of the stars in our galaxy will be occupied.

Of course, this is an approximation. Not all stars will be suitable as migration destinations. Some stellar encounters will be between occupied planetary systems. But it does indicate that not many space-capable, long-lived civilizations must be postulated to arrive at an occupied galaxy.

One might argue that humanity is the oldest apace-faring civilization in the galaxy. But this is unreasonable because, as noted by Vityazev et al. (2018), most local stars in Gaia DR1 are 1 billion years or more older than the Sun. The outer solar system could be occupied by large numbers of extraterrestrial space habitats. Our current knowledge of these distant regions is primitive at best (Matloff, 2019).

But there is an issue associated with the scenario discussed above. If local stars are generally much older than our Sun, if potentially habitable planets are as common as they seem, if long-duration interstellar transport is not impossible, if the resource-rich region of our Sun's outer solar system could be inhabited, astronomers can then no longer reject UFO (or UAP) reports out of hand on the basis of the speed-of-light limitation. If our solar system's Kuiper Belt is inhabited by a civilization ~1 billion years in advance of humanity, they might frequently visit the inner solar system. Acceptance of this suggested paradigm shift would entail acceptance of

the possibility that terrestrial evolution has long been directed by advanced extraterrestrials. This would not be easy for mainstream science and our socio-political systems to accept.

4. Conclusions and Remarks

In contemporary astrophysics, the dark matter hypothesis is often utilized to address anomalies. This undetectable but apparently omnipresent "substance" apparently has properties capable of scientific magic, when it comes to addressing the cause of anomalies.

Some might be tempted to invoke dark-matter magic as a possible explanation for anomalous stellar acceleration. But this is unlikely to succeed. First, this elusive material is generally invoked to explain stellar motion in the outer reaches of spiral galaxies (Chaisson&McMillan, 2008). Attempts to locate this material (which is thought by many to comprise >80% of the Universe's mass) within the solar system by applying Newton's shell theorem to the study of comet and extra-solar-probe trajectories have come up empty (Matloff, 2014).

It is not impossible that some configuration of dark matter might be invoked to explain stellar acceleration in our galactic vicinity. But gravity is a mutual force. If dark matter accelerates stars, stars decelerate dark matter. This material would then be evident deep within the galaxy.

Science-journalist Paul Glister coordinates the Centauri-Dreams astronomical/astronautical blog (Centauri-Dreams. org). The April 26, 2019 issue of this influential blog, which was entitled "Probing Parenago: a dialogue of Stellar Discontinuity", considered the ramifications of Vityazev er al. (2018). On April 20, 2021 the blog's issue, which was entitled "How to Explain Unusual Stellar Acceleration" was devoted to a discussion of Kezerashvili et al. (2021).

In the 2019 blog issue, some correspondents favored the extraterrestrial civilization hypothesis". A few correspondents in the 2021 blog issue apparently did not favor the extraterrestrial civilization hypothesis because it seemed unlikely to them that so many distinct occupied planetary systems would coordinate their activities in unison. Astronomers might check this possibility by searching for signatures of megastructures located in the vicinity of nearby stars.

It was also suggested by several 2021 blog correspondents that interaction between stars and the galactic magnetic field might be considered as a possible mechanistic explanation for the anomalous stellar acceleration discussed by Vityazev et al., (2018). Such an explanation does not seem likely.

A Sun-like star has a mass of ~ 2 x 10^{30} kg (Chaisson & McMillan, 2008). The magnitude of the interstellar magnetic field is estimated by Ferriere (2015) to be ~ 5×10^{-10} T. According to Stoldolkiewicz (1973), this field is likely parallel to our galaxy's spiral arm. Neslusan (2001) estimates that a Sun-like star can have an electrical charge of about $q = 77$ Coulombs. Substitution this charge in the standard equation for magnetic force $\boldsymbol{F} = q\boldsymbol{v} \times \boldsymbol{B}$, where $\boldsymbol{v}$ is the object's velocity (~220 km/s in the case of the Sun) and $\boldsymbol{B}$ is the interstellar magnetic field, on an electrically charged object indicates that magnetic interaction fails to explain the anomalous stellar acceleration by many orders of magnitude.

It must be remembered that the anomalous stellar acceleration reported by Vityazev et al (2018) must be regarded as provisional until they have been verified. But if these results stand up under additional scrutiny, developing a mechanistic explanation will be most challenging. The possibility of a major change in the astrophysical paradigm perhaps similar to the alternatives presented here cannot then be ignored.

Acknowledgements: The authors are grateful for discussions with Kelvin Long, who was a co-author on Kezerashvili *et al.* (2021).

Received September 21, 2021; Accepted November 7, 2021

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