THE NONLOCALITY OF PARENGO'S DISCONTINUITY AND UNIVERSAL SELF-ORGANIZATION

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ABSTRACT

Parenago's Discontinuity refers to anomalous stellar motions. Redder, cooler, less massive stars revolve around the center of the Milky Way galaxy somewhat faster than hot blue stars. Data from ESA's Hipparcos space observatory confirms this anomaly for main sequence stars out to distances of ~250 light years and giant stars out to >1,000 light years for samples of a few thousand stars. The author has proposed that a possible cause for this is universal self-organization. To falsify an alternative hypothesis that Parenago's Discontinuity is caused by density waves in the interstellar medium that drag less massive stars along at a faster rate, the author has elsewhere considered the diffuse nebulae sample in the Messier Catalog. Here, a similar process is performed for nebulae in the more extensive Herschel catalog. It seems very unlikely that dense star forming regions in normal spiral galaxies are large enough to produce Parenago's Discontinuity over a sufficiently large volume. Alternative hypothesis including starbursts, an active galactic core during a possible Seyfert phase earlier in the Milky Way's history and galactic collisions also seem unlikely. If the new ESA Gaia space observatory supports with position and motion observations of ~1 billion Milky Way stars the hypothesis that Parenago's Discontinuity is a galaxy-wide phenomenon, the possibility that the universe is in some way self-organizing will be advanced.

Keywords: Parenago's Discontinuity, Hipparcos ,Gaia Spacecraft, Universal Self-Organization

1. INTRODUCTION

Parenago's Discontinuity refers to anomalistic stellar kinematics. At least in the solar neighborhood (out to ~250 light years from the solar system), cooler, lower mass yellow-red stars, such as the Sun, circle the center of the Milky Way galaxy at a faster rate than their hotter sisters [1]. This discontinuity for main sequence stars using data from the European Hipparcos space observatory and *Allen's Astrophysical Quantities* has been discussed[1-3].

One suggested explanation for this anomaly is the "density wave hypothesis". Galactic dust clouds have a higher density than the surrounding inter-cloud medium. If a dense dust cloud drifts through a star grouping, the high-density cloud will tend to pull the lower-mass stars along at a faster rate than more massive stars [4, 5]. A comprehensive spectroscopic study of spiral arms in a small number of external spiral galaxies does not support the density-wave hypothesis [6].

For spiral arms density waves to succeed as an explanation of Parenago's Discontinuity, high-density interstellar clouds must be larger than star fields demonstrating Parenago's Discontinuity. A preliminary examination of interstellar clouds in Messier's listing [7] does not support this supposition. But Messier's listing of comet-like nebulae includes only 104 celestial objects. The research reported here discusses a similar study using data in the much more comprehensive atlas of Herschel deep-sky objects, which contains more than 2,500 listings.

Although the data presented here cannot rule out a local explanation of Parenago's Discontinuity, it certainly does not support one. When one factors in a Hipparcos-based observational study of the motions of giant stars out to distances greater than 1,000 light years {8}, the density-wave hypothesis becomes less probable as an explanation.

These results support non-local explanations for Parenago's Discontinuity such as stellar volition [3] or universal self-organization [9], both of which support the concept of panpsychism-- that consciousness pervades the fabric of the universe.

2. REDUCING THE HERSCHEL DATA

Several steps were involved in the reduction and analysis of the Herschel catalog data, using a 2011 version authored by James Mullaney and Wil Tirion [10]. The first step was to separate existing galactic diffuse nebulae from other objects including globular clusters, planetary nebulae, external galaxies and nebulae in the extra-galactic Magellanic Clouds. The Herschel designation for each nebulae was then recorded: h nebulae were cataloged by John Herschel, H nebulae were cataloged by William Herschel. Some of these objects were initially discovered by Caroline Herschel but incorporated in John's or William's lists. In the case of multiple designations for an object, only one was included. New General Catalog (NGC) designations were then recorded, as were Messier (M) numbers and popular names, when available. This information is presented for the 38 diffuse Herschel nebulae in Table 1, as are the celestial coordinates.

A literature search was then conducted to obtain estimates of nebulae diatances and sizes. Web references listed in Table 1 for various nebulae include W: Wilipedia (W, Sp: spider.seds.org, U: u-Strasberg.fr/simbad/, Ds: dso-browser.com, H: Hubblesite.org/newscenter/archive/releases/2000/10/fastfacts/, An: annesastronomynews.com, Ap: apod.nasa.gov, Do: docdp.net (the Deep Sky Observer's Companion), At : atlasoftheuniverse.com, St: spacetelescope.org, Ng: ngicproject.org, Ph: phys.org/news/2013-06-ngc-mini-starburst-region.html, and No: noao.edu/outreach/aop/observers/n6559.html. Original research papers utilized to obtain nebulae size and distance estimates are cited in Table 1 and listed in the References for this paper. This exercise was performed to test the accuracy of listings for nebulae data in Wikipedia. In general, Wikipedia is a good source for this information.

The next step in reducing the Herschel data was to order the estimated sizes of the nebulae in Table 1. The fraction of these nebulae with diameters greater than selected values is plotted in Figure 1. Since nebulae size estimates vary in different references, a similar plot is presented in Figure 1 that is based upon bright galactic diffuse nebulae in the larger sample of NGC objects tabulated in the on-line source www.atlasoftheuniverse.com/nebulae.html

3. INTERPRETING THE RESULTS

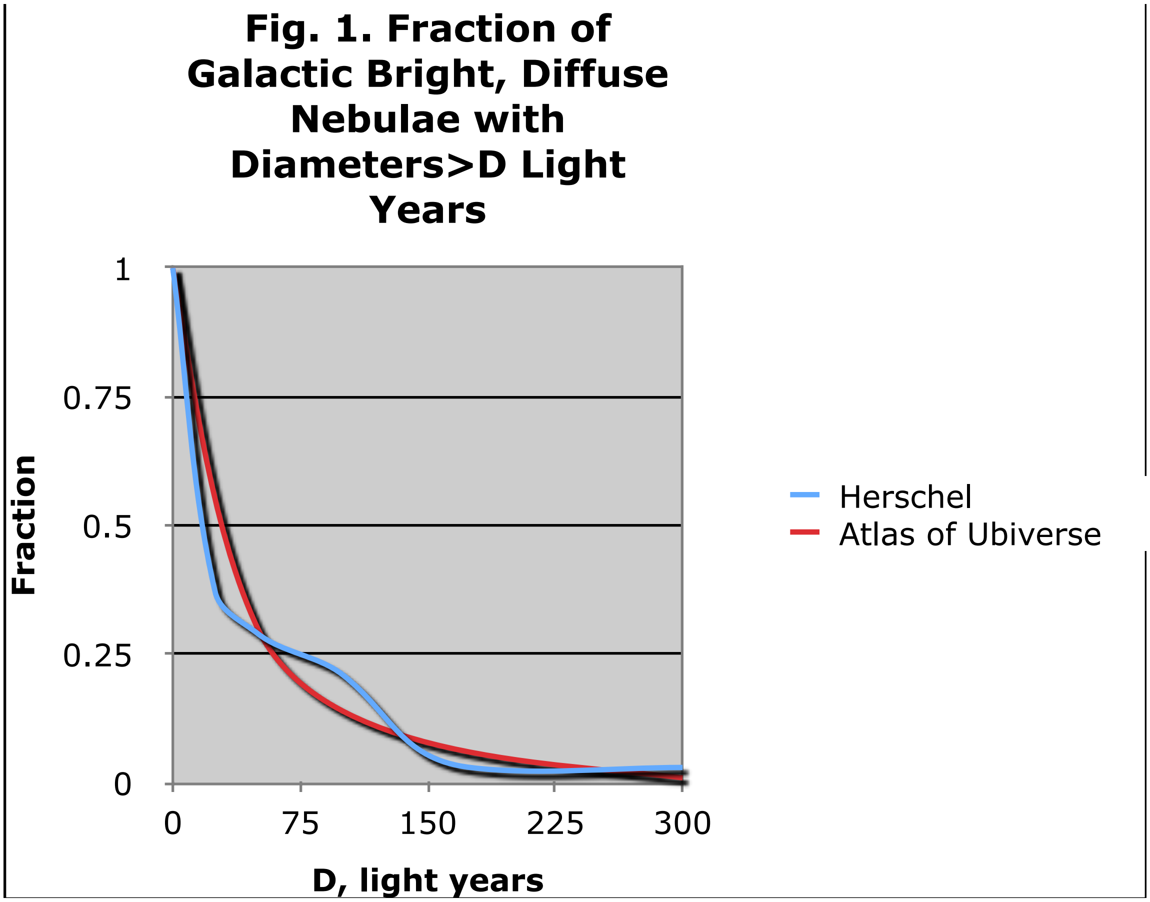
First, it is obvious from Table 1 and Figure 1 that typical diffuse nebulae sizes in the Milky Way galaxy are small in the cosmic sense. For both samples presented in Figure 1, the median nebulae diameter is less than about 20 light years. No more than 10% of the nebulae have diameters larger than 100 light years and only one—the Eta Carinae circum-stellsr nebulae has a diameter larger than 400 light years. None are as large as the ~500 light year diameter sphere of stars centered on the Sun shown by Binney et al [1] to demonstrate Parenago's Discontinuity.

The nearest diffuse nebula large enough to accommodate the stars in Binney et al's sample [1] is the Tarantula Nebula (30 Doradus) This object, perhaps the largest "starburst region" in the Local Group of galaxies, is located in the Large Magellanic Cloud, which is at a distance of about 200,000 light years. According to one source, the diameter of this object is about 800 light years, with extending filaments and streamers increasing the total size to about 2,000 light years [17]. Although Binney's sample of main sequence stars [1] could fit within by this extra-galactic object, Branham's sample of giant stars extends over a greater range and could not fit [8].

Table 1. Galactic Diffuse Nebula from the *Cambridge Atlas of Herschel Objects*. Literature Sources are Denoted [11], [12], etc. and are Listed in the References. Web sources are Abbreviated W, Ap etc. and are Defined in Text.

Hers. #	NGC/M	Name	RA	DEC	Distance	Max. Size	Source (Dis/Size)
HI-258	1491		04^h 03.4’	+51° 19^m	11400 ly	30 ly	W, [11]
HI-217	1579		04 30.2	+35 16	6850	3	Ap
HV-49	1624		04 40.4	+50 27	21500	30	W, {12}
HV-32	1788		05 06.9	-03 21	1300	4	W, Sp., [13]
h351	1893		05 22.7	+33 24	14000	100	Ap
HI-261	1931		05 31.4	+34 15	~7000	~6	W, [14], U
h360	1976/M42	Orion	05 35.4	-05 27	~1500	~14	[15]
HV-30	1977	Running Man	05 35.5	-04 52	~1500	~17	W, [16]
HV-34	1990		05 36.2	-05 16	~1340	~19	W, [17], Ds
HV-33	1999		05 36.5	-06 42	~1500	~0.9	W, H
HIV-24	2023		05 41.6	-02 14	1500	4	An
h2942	2024	Flame	05 41.9	-01 51	900-1500	<13	W, [17], u
h368	2068/M78		05 46.7	+00 03	1600	4	[15]
HIV-19	2170		06 07.5	-06 24	2400	1	Ap
HIV-36	2071		05 47.2	+00 18	1500	3	W, [18,19]
HV-20	2185		06 11.1	-06 13	2700	2	W, [20]
h-392	2239	Rosette	06 31.0	+04 57	4700	125	[21], At
HIV-2	2261	Hubble Vari.	06 39.2	+08 44	2500	1	W, St, U
HVIII-5	2264	Cone	06 41.1	+09 53	2700	8	W, Ap
HV-21	2359	Thor Helmet	07 18.6	-13 12	12000	30	W, [22]
h3122	2579		08 21.1	-36 11	22000-28000	150	[23]
h3131	2626		08 35.6	-40 40	3300	5	W, Ng, [24]
h3323	3372	Eta Carinae	10 37.3	-58 38	9000	460	At
h3324	3576		11 11.8	-61 23	9000	100	At
h3640	6188		16 40.5	-48 47	4000	22	W, Ap
h3678	6334	Cat’s Paw	17 20.5	-35 43	4500-6500	63	Ph
h3682	6357	Lobster	17 24.6	-34 10	~8000	~56	W, Ap
HIV-41	6514/ M20	Trifid	18 02.3	-23 02	2300	19	[15]
H1996	6559		18 10	-24 06	5000	5	W, Ap, No
HV-9	6523/M8	Lagoon	18 03.8	-24 23	4850	120	[15]
h2006	6611/M16	Eagle	18 18.8	-13 47	6600	13	[15]
h2008	6618/M17	Omega	18 20.8	-16 11	5900	75	[15]
HV-37	7000	North Amer.	20 58.8	+44 20	1900	130	At
HIV-74	7023	Iris	21 00.5	+68 10	1300	6	W, Ap
HIV-25	7129		21 41.3	+66 06	3000	10	W, Ap
HVIII-27	7380	Wizard	22 47	+58 06	7200	100	An
HII-706	7538		23 13.5	+61 31	9100	10	[25]
HIV-52	7635	Bubble	23 20.7	+61 12	7800	10	W, [26]

One must be cautious in the evaluation and interpretation of these results. Both Binney et al and Branham apply astrometric data from the Hipparcos ESA space observatory [1,8]. Only a few thousand stars are in the samples of main sequence and giant stars used in both studies. The radial solar distances of many of the giant stars in the sample are listed in Branham’s studies as more than 1,000 light years. It is unclear how accurate Hipparcos-based distance and kinematics interpretations are for such distant stars. But the current limited dataset points to a galactic rather than a local reality for Parenago’s Discontinuity.



4. CONCLUSIONS: GAIA DATA AND UNIVERSAL SELF-ORGANIZATION

The ESA Gaia space observatory is now operational [27]. It is hoped and expected that this spacecraft will provide accurate distance and kinematics data for ~1 billion stars in the Milky Way galaxy.

If this spacecraft confirms that Parenago's Discontinuity is a galaxy-wide rather than local phenomenon, attempts will certainly be made to explain it without invoking universal self-organization. Many of these attempts will be constrained by astrophysical knowledge.

For example, some may consider the possibility that the Milky Way was probably a Seyfert galaxy earlier in its history. Although Seyfert galaxies have a higher star formation rate than "normal" spirals, the larger star-forming nebulae in Seyferts are likely confined to the near-nuclear region rather than the spiral arms [28].

Another possibility that will be raised is that our galaxy at an earlier time in its history had starburst regions. But these regions are typically 0.1-2 kiloparsecs in size, not enough to explain a galaxy-wide phenomenon [29].

Finally, computer simulations do indicate that galactic collisions result in greatly enhanced rates of star formation [30]. But if our galaxy was involved in such a catastrophe, how did it maintain its spiral shape?

The prospects for the related concepts of volitional stars, universal self-organization and panpsychism are certainly supported by the Hipparcos data discussed above and will be further advanced if Gaia discovers that Parenago's Discontinuity is a galactic phenomenon. But much additional work is certainly required before mainstream science will adopt these radical proposals.

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