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WHY DON'T CLUMPS OF CIRRUS DUST GRAVITATIONALLY COLLAPSE?

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Abstract. We consider the Herschel-Planck infrared observations of presumed condensations of interstellar material at a measured temperature of approximately 14 K (Juvela et al., 2012). The standard picture is no longer tenable that the material is cirrus-like clouds of ceramic dust that are responsible for Halo extinction of cosmological sources (Finkbeiner, Davis, and Schlegel 1999). Why would such cirrus dust clouds be in condensations at 14 K temperature, and why do these condensations not continue their collapse gravitationally to a point? Why do the particles not collide and stick together, as is fundamental to the theory of planet formation (Blum 2004; Blum and Wurm, 2008) in pre-solar accretion discs? Evidence from 3.3 μm and UIB emissions as well as ERE (extended red emission) data point to the dominance of PAH-type macromolecules for cirrus dust, but such fractal dust will not spin in the manner of rigid grains (Draine & Lazarian, 1998). IRAS dust clouds examined by Herschel-Planck are easily understood as dark matter Proto-Globular-star-Cluster (PGC) clumps of primordial gas planets, as predicted by Gibson (1996) and observed by Schild (1996).

1. Introduction

When the IRAS infrared satellite (Soifer, Houck, and Neugebauer, 1987) discovered strong evidence of a new component of infrared emission, it was already understood that such cold emission was found in star forming regions, and so was attributed to dust. Hundreds of infrared galaxies were soon discovered by IRAS emitting $\geq 95\%$ of their radiation over 7 decades of luminosity from $10^6 L_\odot$ to $10^{13} L_\odot$. What is the source of all this power? Despite the low resolution of imaging in the DIRBE experiment, the emission was found to be thinly extended across the entire Galaxy Halo in long filamentary structures reminiscent of cirrus clouds. An improved representation of this can be seen in the IRAS map of $\approx$ 15K emission published as Fig. 1 of Juvela et al (2012), arXiv:1202.1672.

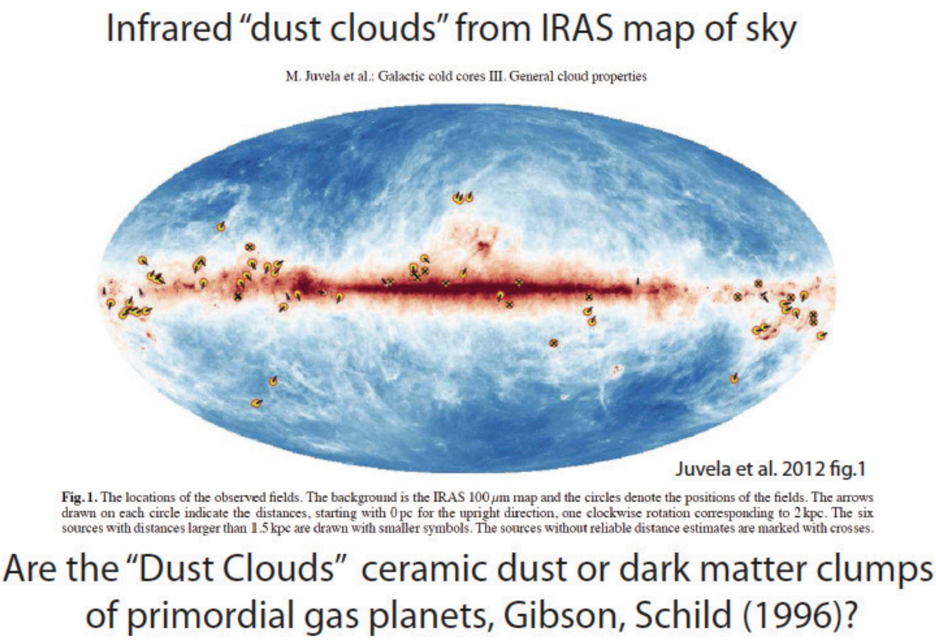

Figure 1. IRAS 100 micron map of the sky (Juvela et al. 2012 fig. 1).

We have previously proposed (Gibson 1996, Schild 1996) that the observed structures are in fact meta-stable clumps of Jeans Mass planet clumps (PGC Proto-Globular-star-Clusters) formed primordially at the plasma to gas transition, comprising the missing baryonic dark matter of all galaxies. The clumping is initiated by Hydro-Gravitational-Dynamics (HGD) fragmentation of primordial plasma protogalaxies (Gibson 1996), and is fractal (non-Gaussian) in statistical properties, and concentrically structured, in clumps of clumps. An individual Jeans mass clump at 3–10 K will consist of a trillion Earth mass frozen hydrogen spheres originally detected (Schild 1996) in quasar microlensing. These will be in quasi-stable equilibrium and have survived as coherent Halo structures for 13.7 billion years, and when disturbed become the Giant Molecular Clouds that host star formation in an accretional cascade from planet mass

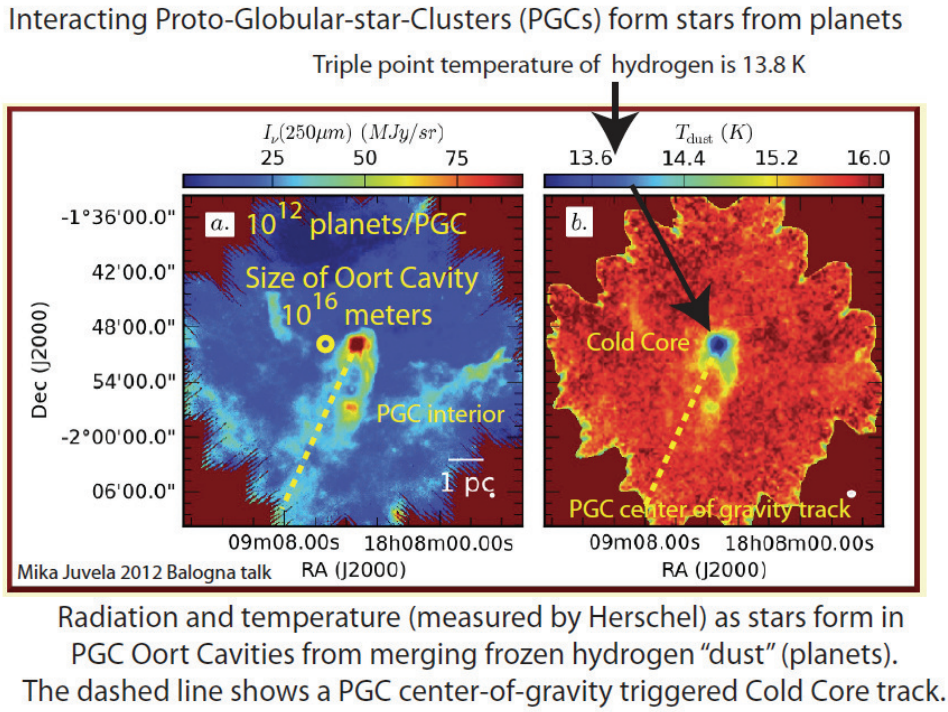

Figure 2. Herschel-Planck infrared images of radiation and temperature within PGCs, reported by M. Juvela at the Planck 2012 Cold Cores Project meeting, Balogna. Image a (left). An intensity map showing the track of a core (dashed line) through a PGC. Image b (right). shows the radiation temperature of the Cold Core which is brighter at the triple point of hydrogen, 13.8 K, than the surroundings which are at higher temperature but lower surface brightness. The HGD cosmology interpretation is that mergers of cold dark matter frozen planets, rather than ceramic dust, best explain the radiation and temperature patterns.

to stellar mass.

With much higher resolution, particularly of the Herschel telescope, the "Cirrus Dust" is revealed to be a network of small condensations carefully analyzed for regions within the disc and halo of our Galaxy by Juvela et al. (2012). The clumps were found and studied at a number of distances and environments and have shown surprising consistency in their properties. From SPIRE photometry at wavelengths 250, 350, and 500 microns [combined with AKARI photometry at 90, 140, and 160 microns], temperatures estimated for 71 regions averaged (Table 2 column 6) about 14K, though estimates, where a background temperature was subtracted, were 1.5 K lower. A slightly different temperature was determined from spectral energy distributions that introduce the longer wavelength WMAP flux densities (Veniziani et al., 2010, 2012)

It is surprising that so little diversity was found in the estimated temperatures. Because the radiation environment would be expected to be very different for sources in the Galactic plane than for sources above the plane, it would be easier to understand the temperature as being thermo-statically controlled by the 13.8 K triple point phase transition of Hydrogen, as proposed by Nieuwenhuizen et al. (2011). At present it is accepted that the dust temperature is maintained primarily by radiation from spinning dust particles (Hoyle and Wickramasinghe, 1970; Schlegel et al., 1997; Draine & Lazarian, 1998).

An elongated rigid grain with average moment of inertia I acquires a spin ω by energy equipartition with a hot gas of temperature T governed by the condition $\frac{I}{2} \times \omega^2 = 3kT/2$. For sufficiently small grains (small I) we may have rigid grains spinning at far infrared, microwave and radio frequencies. The ability of these grains, carrying a net electric charge and a non-zero dipole moment, to emit electromagnetic waves has been recognised for a few decades and is not in dispute (Hoyle and Wickramasinghe, 1970; Draine and Lazarian, 1998). However, in order to reproduce the observed flux data from SPIRE and AKARI photometry, we require implausible and artificial constraints on any spinning grain model. Moreover, observations of 3.3 μm and other UIB emissions, as well as ERE (extended red emission) in cirrus clouds imply that cirrus dust is mostly composed of PAH macromolecules of undefined provenance (Szomuru and Guhathakurta, 1998; Smith et al, 2004; Wickramasinghe, 2010), with only minor contributions from silicate dust. Large PAH molecules with an inherent fractal structure will not behave like small mineral grains, so a rigid spinning grain model will not apply in this case. Thus we offer an alternative to the accepted view of the 14 K clumped sources as spinning cirrus dust.

More surprising were the morphologies of structures encountered. Independently of where the clumps were located, whether at high or low galactic latitude, the clumps were found in small clusters of clumps and also in filamentary structures, though isolated clumps are more common at high galactic latitudes (Juvela et al. 2012).

Although some of the clumps are quiescent at the low 14K temperature, most are apparently sites of star formation, as evidenced by the existence of emission at mid-infrared wavelengths. The warmer emission co-exists with the cold 14K clumps.

About half of the fields studied show a filamentary structure which was not predicted for "dust cirrus clouds" before the HERSCHEL detection. The individual filaments tend to be broken into individual knots of strong emission, also not predicted before their observational discovery. The typical filament width is 1/4 pc, measured as an infrared brightness FWHM, and sub-structure within and along the extended filament structures is commonly found. This observed size closely matches the Oort cavity scale $L_{Oort} \approx (M_{\odot}/\rho_0)^{1/3}$; which is the size of the cavity produced in a PGC cloud of dark matter planets of density ρ_0 when they merge to form a solar mass star, as shown in Fig. 2.

In contrast with the view of the nature and distribution of interstellar dust implied by the HERSCHEL observations, the older view is very different. That prevailing view is that interstellar dust has condensed into cores of planets orbiting stars in their pre-stellar discs, and that this occurs in a process of grain growth, collision and sticking (Blum and Wurm 2008), on a time scale of approximately 1 million years, set by the observed ages of young star-forming regions. Based upon laboratory data, it follows that the porosity (or volume filling fraction) has a value of approximately 0.5, or twice the density of liquid water. Experiments with crushing the ensembles of growing dust particles of SiO_2 showed that filling factors in the range 0.2 - 0.3 are measured, with corresponding porosities of approximately 0.66 and densities of 1.5 g cm^{-3} (Blum, J. 2004). These mechanical properties of interstellar cirrus dust are presumed to underlie the process of planet formation.

However it is obvious that the HERSCHEL-observed 14 K temperature cannot be maintained by cirrus dust whose temperature is maintained by spinning of the dust particles. The Herschel image shows that the dust exists in clumps of particles presumed to have been produced in collisional interaction, and the presumed spin would have not credibly been maintained during the phase of crushing by the self-gravity of the clumps. Thus we examine an alternative to the identification of the radiating structures as dust.

2. Alternative Explanation: Primordial Planets contained in Jeans Clusters (PGCs)

An alternative to the cosmic dust condensation concept producing the compact centrally condensed clumps of cirrus dust whose thermal emission at 15 K espoused by Juvela et al. (2012) and others, is the concept of gas spheres of planetary mass clumped in proto-globular-star-cluster (PGC) Jeans clusters related to the ordinary globular clusters observed in all galaxies. As originally proposed by Gibson (1996) from hydrodynamical considerations, the structures in question would have formed in weak turbulence at the plasma-gas transition at z = 1100 on scales of Jeans mass, $5 \cdot 10^5 M_\odot$ and additionally at planetary mass, $10^{-6} M_\odot$. Such structure was observed in quasar microlensing (Schild 1996) and described as "rogue planets".

Since the original discovery, the existence of rogue planets has been confirmed in 4 additional quasar lens systems having sufficient data to indicate a time delay, but also with sufficient accuracy to reveal the rapid microlensing (see Paraficz et al., 2005, for further references). Their wider detection and properties have been further elucidated by Nieuwenhuizen et al. (2011).

The hydrodynamical theory that predicted their existence has further implication bearing upon the nature of structure that should be evident in the low-z universe. Following their formation as turbulent residual perturbations they would have collapsed on a $1/\sqrt{G\rho}$ time scale of approximately 10^5 years, and thereafter cooled throughout the 13.7 Gyr history of the universe, with their cooling lagging slightly behind the lowering Cosmic Background Temperature of the Universe. An important temperature in the physical chemistry of the universe, the triple point for gas-solid phase transition in hydrogen gas at 13.8K, would set the thermostat for hydrogen spheres with warm cores trying to radiate away their original heat of gravitational collapse. The accumulated metals in their warm cores would also produce heat by radioactive decay (Wickramasinghe et al. 2010). Because the objects are observed to be cooling and radiating at 14K, a temperature gradient in their atmospheres to drive outward heat flow might leave a detectable signal of slightly higher temperature, easily confused with core-shine.

3. Comparison of Predicted Structure to Sub-mm Observations

The Juvela et al. (2012) analysis of the clumping of matter seen at the wavelength peak of 15K emission gives an important perspective on the evolution of primordial structure and its evolution to presently observed (local umiverse) structure. They report structure dominated by knots of 0.32 pc diameter in clumps and filaments of characteristic diameter 6.1 pc. These must have evolved into the globular clusters seen today with a mean diameter of 6.6 pc. (All dimensions are expressed as FWHM and the knot and clump diameters are averages from Juvela et al tables 2 and 3. The quoted mean diameter for globular clusters is from the Harris 1996 compendium). Thus we conclude that the clumps of knots seen today as 15K emission are precursors of today's globular clusters.

4. Comparison of predicted structure to red dots; Estimation of the mass of LMC Missing Baryons

From the above considerations we may conclude that that the cosmic structures that have recently been observed cannot reasonably be understood as clouds of spinning mineral dust particles. The mean density of matter in a globular cluster today is a better indicator of density than the problematic mass estimates in Table 2 of Juvela et al., (2012), which show a very large variance.

From HGD cosmology the mean PGC density is 5×10^{-17} kg m^{-3} and the corresponding gravitational free-fall collapse time scale is 30,000 years. Thus any structure relevant to time scales of star formation cannot survive gravitational collapse, and any spinning charged dust must consequently slow and change its radiating temperature. This is not compatible with structures having the same sizes and temperatures being found in the Galaxy's halo and disc.

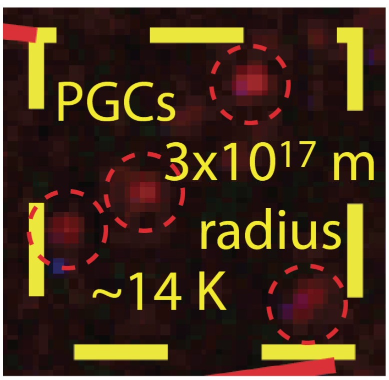

Figure 3. LMC dark matter proto-globular-star-cluster (PGC) "red dot" sizes, temperatures and brightnesses falsify spinning mineral and PAH cirrus dust models.

Highest resolution ESO Herschel images of the Small Magellanic Cloud (SMC) have been discussed by Gibson (2012), where the pattern of glowing "red dot" objects is seen. The SMC and Large Magellanic Cloud (LMC) galaxies are below the Galaxy disk plane in Fig. 1 interpreted as "cirrus dust" clumps. Figure 3 shows $\approx$ the same size and density of PGC "red dots" that exist in the SMC. We interpret these, not as mineral or PAH dust clouds, but as PGC clumps of planets in $\geq$ 14 Gyr metastable equilibrium. Mergers of the planets cause the infrared brightness shown in Fig. 1, and the star formation shown in Fig. 2. The clumps are remarkably uniform, with size 3×10^{17} meters in radius, matching $L_{PGC} \approx (M_{PGC}/\rho_0)^{1/3}$, as expected from HGD cosmology and in further contradiction to the standard cirrus dust models.

5. Acknowledgement

We acknowledge and thank Dr. W. Harris for maintaining the Globular Cluster Data Base, available at: http://physwww.mcmaster.ca/We have used this data base to determine the mean globular cluster diameter.

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