Searching for Quasi-Dyson Spheres

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1 Abstract

A neighboring star orbited by very large numbers of space colonies hosting water based life should exhibit spectral signatures distiguishable from dust and debris. These signatures depend only on thermodyamics and may be detectable by current or soon-to-be operational instruments, making the existence of very large civilization of orbital space colonies a testable hypothesis. We describe the beginings of a computerized search of online astronomical databases to detect such civilizations.

2 Introduction

Suppose

1. there is no technological short-cut to the laws of thermodynamics, as we know them
2. our civilization continues to expand for perhaps a million years, a small fraction of the lifetime of a star
3. we start building orbital space colonies in the next thousand years or so

In this case, we might be observable to a civilization orbiting a nearby star possessing instruments similar to what we have today. Turning this around, if civilizations similar to ours a million years hence are common in our stellar neighborhood, we may be able to observe them with current or soon-to-be deployed instruments. Specifically, a star orbited by very large numbers of space colonies may have excess emissions in the infrared or even be dimmed. Such a star may be described as a Quasi-Dyson Sphere (QDS). Freeman Dyson

[Dyson 1960] proposed artificial structures completely enclosing a star, but such structures are gravitationally unstable [reference]. However, sufficiently large numbers of orbital colonies around a star would partially block and convert a star's energy. If n% of a star's energy is blocked, we may say that this star is a n% QDS. Given instruments that can detect an n% QDS, the existence of such civilizations, at least in our stellar neighborhood, becomes a testable, falsafiable hypothesis.

The search for extraterrestrial intelligence (SETI) has been dominated by the attempt to detect radio signals [reference] on the questionable assumption that other civilizations will attempt deliberate communications and/or that their communication systems are inefficient. While it is true that our present radio frequency communication systems are inefficient in the sense that much of the signal does not reach the intended recipients but is rather broadcast into space, this inefficiency is a function of our current technology and is unlikely to last more than a few centuries or millenia. As a fraction of the multi-billion year life of a star, this is a insignificant length of time. Thus, even if we point our radio telescopes in the right direction, we are unlikely to happen to be at the right time. By contrast, the emissions this paper examines for detecting QDS, should last millions or even billions of years, although only a restricted set of potential civilizations will emit these signals.

3 Infrared Excess

One approach to detecting a QDS is to look for the infrared emissions produced by artificial thermal radiators. Assuming there is no work-around to our laws of thermodynamics, colonies must absorb a star's energy (or produce new energy), use it and reject the heat to deep space. The heat must be rejected at temperatures below utilization temperatures. The higher the temperature the more efficient the heat rejection. For water based life, therefore, the temperature of the heat rejection systems can be assumed to be in the range 273-373K (the temperature of liquid water). Thus, a QDS star's energy output curve should be somewhat different than a purely natural solar system, with a small artificial peak in the 10-20 micron range. The hight of the peak is related the completeness of the QDS. Once a star with such an infrared excess is found, it is necessary to distinguish between the infrared excess of space colonies and naturally occurring dust or debris. There are two approaches to this discrimination: the temperature range of the source and the age of the star. The temperature of the dust is determined by the distance from the star and the size and composition of the dust. From these parameters the expected spectrum can be calculated. Since any given thermal technology should have an optimal temperature, artificial emissions should be closer to black body radiation. Thus, high spectral resolution data between 10-20 microns, as is available from the Keck infrared instrument [reference], should be able to distinguish between natural debris and large numbers of space colonies. Second, dust is usually associated with younger stars. If our star develops a QDS it will have taken at least 5 billion years. Thus, a reliable means for determining the age of stars would help distinguish QDS from dust. The literature contains at least two attempts to find an infrared excess associated with a QDS.

1. Jugaku, Noguchi, and Nishimura have searched 53 nearby stars with a 1.26 m infrared telescope in Japan and examined IRAS data for 135 more looking for a 10-20 micron infrared excess [Jugaku, Noguchi, and Nishimura 1995]. The sensitivity of the instruments should be sufficient to detect a 1% QDS. No candidates have yet been found.

2. Slysh [Slysh 1985] examined the IRAS data for 100% DS candidates, specifically 0507+528 P05, 0453+444 P03, 0536+467 P05, and 0259+601 P02 without finding a candidates, however noted that G 357 .3-1.3 [Gautier et al. 1984] is strong source with a 220K blackbody spectrum and claims this is a good 100% QDS candidate, however the temperature is suspiciously low. Slysh notes that it is difficult to distinguish a 100% QDS from circumstellar dust shells around an evolved red giant star.

4 Temperature/Luminosity Anomaly

Another approach to finding an n% QDS, albeit with high n, is to search for main sequence stars with low luminosity relative to other main sequence stars of the same temperature. A main sequence star's mass determines it's temperature [reference] and therefor it's absolute magnitude. If the distance to a star is accurately know, it's absolute luminosity can be calculated from it's apparent brightness. The European Hipparchos satellite [reference] calculated very accurate distance to nearby stars using parallax. We have extracted 299 stars from the Hipparchos catalogue the exhibit low luminosity relative to other stars with similar temperatures. The stars were selected to have:

$$p \geq 20 \tag{1}$$

$$T_c = \frac{7300}{B - V + 0.73} \tag{2}$$

$$T_c \leq 8000 \tag{3}$$

$$m_h \leq 27.31 - 0.002149 T_c \tag{4}$$

$$m_h \geq 17.805 - 0.001681 T_c \tag{5}$$

where p is the Hipparchos parallax, $B - V$ is from the Hipparchos catalogue, and m_h is the Hipparchos (absolute) magnitude based on apparent magnitude and the Hipparchos distance. T_c is the temperature as calculated from $B - V$. Fred – need explanation of $B - V$.

With the advent of internet accessible archives of astronomical data, such as the Hipparchos catalogue and the IRAS database [reference], it is possible to design computer searches for candidate QDSs. With new, more powerful infrared instruments becoming available, such as SIRTF [reference], pledged to put their data on the net, new opportunities for inexpensive, computerized search for QDS will become available. Combined with a search for passive signatures of large scale orbital civilizations, we now have a testable hypothesis that can lead the quantification of an upper limit to the density and size of QDS in our stellar neighborhood.

5 Acknowledgements

6 References

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