Planetary Systems in the Universe - Observation, Formation and Evolution
Proceedings IAU Symposium No. 202, ©2004 IAU
Alan Penny, Pawel Artymowicz, Anne-Marie Lagrange, & Sara Russell, eds.

The Visibility of Earth Transits

T. Castellano

NASA Ames Research Center, MS 245-6, Moffett Field, CA 94035

L. Doyle

SETI Institute, 2035 Landings Drive, Mountain View, CA 94043, USA

D. McIntosh

Symtech Corporation, 2750 Alexandria Ave., Suite 104, Alexandria, VA 22314, USA

Abstract. The recent photometric detection of planetary transits of the solar-like star HD 209458 at a distance of 47 parsecs suggest that transits can reveal the presence of Jupiter-size planetary companions in the solar neighborhood (Charbonneau et al. 2000; Henry et al. 2000). Recent space-based transit searches have achieved photometric precision within an order of magnitude of that required to detect the much smaller transit signal of an earth-size planet across a solar-size star. Laboratory experiments in the presence of realistic noise sources have shown that CCDs can achieve photometric precision adequate to detect the 9.6 E-5 dimming of the Sun due to a transit of the Earth (Borucki et al. 1997; Koch et al. 2000). Space-based solar irradiance monitoring has shown that the intrinsic variability of the Sun would not preclude such a detection (Borucki, Scargle, Hudson 1985). Transits of the Sun by the Earth would be detectable by observers that reside within a narrow band of sky positions near the ecliptic plane, if the observers possess current Earth epoch levels of technology and astronomical expertise. A catalog of solar-like stars that satisfy the geometric condition for Earth transit visibility are presented.

1. Introduction

Searches for extraterrestrial electromagnetic transmissions of intelligent origin are confronted with the formidable challenge of an enormous multi-dimensional search space of wavelength, sky location and time of observation. Many authors have developed methods for estimating the expectation of receiving a signal of extraterrestrial intelligent origin based on numerous probabilistic factors. Often overlooked in these analyses is a multiplicative factor that considers the fraction of civilizations beaming signals in our direction at the time we choose to listen (Shostak 1997). Unless a transmitting civilization devotes the enormous energy required to radiate isotropically or beams continuously in our direction we are likely to miss their message. "This enormously depressing factor" as so aptly put by Shostak greatly reduces the probability of successful reception. There is, therefore, great motivation to develop a strategy to select search directions and times. The use of orbital orientations, supernovae explosions, and gamma ray bursts (Pace 1979; Filippova & Strelnitskij 1988; Shostak 1997; Lemarchand 1994; Corbet 1999) have all been suggested as natural markers in time and space to increase the chance of achieving synchronization between transmitting and receiving civilizations. A natural mechanism whereby putative alien civilizations could learn of the existence of the Earth and its life supporting environment would be heartening to the exobiology community in that it might increase the likelihood of messages being broadcast in our direction. A mechanism that does not require an active role on our part would minimize the penalty imposed by our recent rise to technical maturity and the finite speed of light.

2. Earth Transit Visibility

Transits of the Earth across the Sun are visible for a range of angles θ near the ecliptic plane is given by (for circular orbits and a planet radius that is small compared to the solar radius)

$$\theta = \frac{R_{\odot}}{a}$$

where a is the semi-major axis of the Earth's orbit (a = 1 AU = 1.496 × 10^{13} cm and $R_{\odot}$ = solar radius = 6.960 × 10^{10} cm). Transits of the Earth are therefore visible for objects on the celestial sphere within 0.267° of the ecliptic. Table 1 contains 17 spectral type G main sequence stars (representative solar-like stars) that satisfy the above condition based on the *Hipparcos* catalog (Perryman et al. 1997). Planets around solar-like stars are thought to be among the most promising sites for the development of intelligent life because a long main sequence lifetime provides a stable environment for life to develop and evolve.

Intelligent civilizations possessing astronomical expertise equivalent to our own residing on planets around any of the 17 solar-like stars in Table 1 could detect transits of the Earth photometrically. This alone might be enough to warrant interest in our solar system as a potential target for beamed transmissions. If they also possess radio technology and an optimistic and inquisitive nature might they not point one of their radio antennae in our direction and send a message? The solar-like stars in Table 1 may therefore be suitable targets in a search for electromagnetic signals of intelligent origin.

3. Historical Note

Philip Morrison first suggested the use of a artificial modulated orbiting occulting mask as a means for transmitting information in the form of an encoded message to possible inhabitants of the Andromeda galaxy (Morrison 1962). It is interesting to note that a natural orbiting occulting mask called the Earth, has been performing this function for directions very near the ecliptic for some time.

References

Borucki, W. J., Scargle, J. D., & Hudson, H. S. 1985, ApJ, 291, 852

Table 1. Nearby Solar-like Stars within the Earth Transit Viewing Zone

HIP Number	SAO Number	HD Number	Spectral Type	Distance (pc)
18719	76384		G4V	62
20480	76580	27732	G9V	48
60956	138815	108754	G7V	52
69054	158372	123453	G8V/K0V	62
79524	184240	145809	G3V	39
82986	184831	152956	G0V	153
84936	185310	156991	G1V	56
88631	186260	165204	G6V/G8V	75
92001	187226	173206	G3V/G5V	69
95895	188205	183388	G1V/G2V	103
96792	188427	185591	G5V	60
104922	164252	202282	G3V	87
106050	164420	204433	G2V	107
107095	164580	206301	G2V	32
107422	164628	206905	G1V/G2V	78
108005	164708	207921	G3V	156
108619	164802	208965	G5V	199

Borucki, W. J., Koch, D. G., Dunham, E. W., & Jenkins, J.M. 1997, in ASP Conf. Ser. Vol. 119, Planets Beyond Our Solar System and the Next Generation of Space Missions, ed. D.R. Soderblom (San Francisco: ASP), 153

Charbonneau, D., Brown, T. M., Latham, D. W., & Mayor, M. 1999, ApJ, 529, L45

Corbet, R.H.D. 1999, PASP, 111, 881

Filippova, L.N., Strelnitskij, V.S. 1988, ATS, 1531, 31

Henry, G. W., Marcy, G. W., Butler, R. P., & Vogt, S. S. 2000, ApJ, 529, L41

Koch, D. G., Borucki, W. J., Dunham, E. W., Jenkins, J.M., Webster, L., Witteborn, F. 2000, in SPIE Proc. 4013, UV Optical and IR Space Telescopes and Instruments, ed. J. B. Breckinridge & P. Jakobsen (Bellingham, WA: SPIE), 508

Lemarchand, G.A. 1994, Ap&SS, 214, 209

Morrison, P. 1962, Bulletin of the Phil. Society, 16, 58

Pace, G.W. 1979, JBIS, 32, 215

Perryman, M. A. C. et al. 1997, A&A, 323, L49

Shostak, G.S. 1997, in IAU Coll. 161, Astronomical and Biochemical Origins and the Search for Life in the Universe, ed. C.B. Cosmovici, Bowyer, S., & D. Werthimer (Bologna: Editrice Compositori), 719

https://doi.org/10.1017/S0074180900218457 Published online by Cambridge University Press