How Many Planets Did Magrathea Build?

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Abstract

In Douglas Adams's *The Hitchhiker's Guide to the Galaxy*, Arthur Dent learns that Earth was built by Magrathea, a legendary planet that became über-wealthy building custom luxury planets for ultra-wealthy civilizations. We estimate they built one million planets. About sixty billion beings wanted a planet, but heat from assembly limits Magrathea to at most one per year, and finishing details like fjords stretch that to about five years per planet. Only one planet order in 60,000 was approved, and the top 1% of civilizations only bought one about every 2,000 years.

1 Introduction

In *The Hitchhiker's Guide to the Galaxy*, the Magratheans built custom luxury planets for the richest beings in the galaxy. The planets were made of anything from solid gold to soft rubber [1, Ch. 15], built from matter pulled through white holes. One of the Magrathean designers, Slartibartfast, won an award for the fjords of Norway on Earth, the most important planet Magrathea created [1, Ch. 30]. We also have a version of Magrathea in the real world, as an open-source code for modeling planet interiors [2].

We start by comparing how many beings could and would want to buy a planet with how many the Magratheans could reasonably build. Slartibartfast tells Arthur that the Magratheans have been asleep for five million years [1, Ch. 22]. Magrathea built the Earth, which Trillian's pet mice, Frankie and Benji, ran for ten million years before the Vogons blew it up [1, Ch. 31]. When the economy collapsed, and the rest of the galaxy went broke, the Magratheans hibernated until the galaxy could afford them again [1, Ch. 15, 22]. So Magrathea was open from at least 10 to 5 million years ago, and we use $\tau = 5$ Myr.

2 How many beings want to buy planets?

First, we count civilizations with the Drake equation [3],

$$N_{\rm civ} = R_* \, f_p \, n_e \, f_l \, f_i \, f_c \, L \tag{1}$$

where each factor filters the one before it. We use $R_* \approx 2$ yr^{-1}, since the Milky Way forms about $1.65\,M_\odot$ of stars per year [4], mostly smaller than the Sun. Stars have at least one planet on average [5], so $f_p \approx 1$, and about 22% of Sun-like stars have an Earth-size planet in the habitable zone [6], so $n_e \approx 0.2$. The galaxy in the books is crawling with life, so $f_l = 1$. For evolving intelligence and joining the galactic economy, we assume $f_i \approx f_c \approx 0.1$, and assume a civilization lasts $L \approx 10^7$ yr. This gives $N_{\rm civ} \approx 4 \times 10^4$. Give each one $N_{\rm pop} = 10^{11}$ inhabitants, and say the richest $f_{\rm rich} = 10^{-9}$ can afford a planet. Using this ratio, that's about eight humans on Earth. The Hitchhiker's Guide says the richest merchants always got bored with their worlds [1, Ch. 15], so say $f_{\rm buy} = 0.3$ of them order one. Fortunes change hands about once per generation, so with new fortunes every $t_{\rm gen} = 100$ years, the number who wanted a planet is

$$N_{\rm buyers} = N_{\rm civ} \, N_{\rm pop} \, f_{\rm rich} \, f_{\rm buy} \, \frac{\tau}{t_{\rm gen}} \approx (4 \times 10^4)(10^{11})(10^{-9})(0.3)(5 \times 10^4) = 6 \times 10^{10} \tag{2}$$

3 What slows down a planet factory?

Making Earth from pure energy would take $M_\oplus c^2 \approx 5.4 \times 10^{41}$ J. Magrathea orbits the binary stars Soulianis and Rahm [1, Ch. 16], which output $2L_\odot \approx 7.7 \times 10^{26}$ W if both are Sun-like. With perfect

efficiency, that's 22 Myr per planet, 17 Myr longer than τ. Instead, the Magratheans pull matter through white holes [1, Ch. 15]. However, there is the issue of heat; we don't want magma in our fjords.

Matter falling onto a growing planet speeds up, and when it lands, the kinetic energy turns into heat. Assume a uniform-density planet of mass M and radius R. When the planet has radius r, its mass is $m(r) = Mr^3/R^3$, and a new shell of thickness dr has mass $dm = 3Mr^2dr/R^3$. Falling in from infinity, it loses $dU = Gm(r)dm/r$. Integrating gives the binding energy of a uniform sphere.

$$U = \int_0^M \frac{G}{r} m \, dm = \int_0^R \frac{G}{r} \left(M \frac{r^3}{R^3} \right) \left(\frac{3Mr^2}{R^3} \right) dr = \frac{3}{5} \frac{GM^2}{R} \tag{3}$$

For simplicity, assume $U = U_\oplus \approx 2.2 \times 10^{32}$ J. With $c_p \approx 1200$ J/(kg K) and $L_f \approx 4 \times 10^5$ J/kg for rock [7, App.], that's enough to heat Earth by 1200 K and melt it about 20 times over.

4 How fast can Magrathea build a planet?

When Arthur visits Earth Mark Two, the mice's replacement for the original, Slartibartfast is already working on Africa [1, Ch. 30], so we expect something on a human timescale. Say Magrathea's cooling method can dump heat at 1% of twin suns' combined power, $P = 0.01 \times 2L_\odot \approx 7.7 \times 10^{24}$ W. Then cooling takes $U/P \approx 1$ yr. We assume parallel builds don't help, as they would share the cooling capacity, so heat caps Magrathea at five million planets. Cooling isn't everything, though. The fjords still need detailing, and with sixty billion would-be buyers, the Magratheans can afford to be picky and take their time. We round down to $t_{\text{build}} \approx 5$ yr per planet, so Magrathea built $N = \tau/t_{\text{build}} = 10^6$, or **one million planets**. That's far fewer than sixty billion, so build time is the limiting factor rather than the customers.

5 Conclusion

With one customer per planet, Magrathea approved one order in 60,000. That's 25 planets per civilization on average. Most civilizations probably never buy a planet, and a few buy a lot. We model the distribution as bimodal; however, it is more likely a right-skewed multimodal distribution, with higher-quality planets being exponentially rarer and the wealthiest civilizations buying fewer but much higher-quality planets. Say only the top 1% of civilizations can afford planets. Then, 400 civilizations each get 2,500 planets, and a wealthy civilization buys a planet every 2,000 years on average. Magrathea built about one million planets, including Earth, but not Earth v2. I hope their 42nd order was an insightful one!

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