

CSC 400 Estimation Questions on Life, the Universe, and Everything

September 3, 2014

Document your sources and describe your reasoning and assumptions in answering the following questions. For uncertain quantities, it is wise to consult more than one source. Do your own calculation rather than looking up the answers (which might very well be wrong), that is, work from the most basic information you can find.

1. Estimate the probability that our solar system has suffered a disruptive interaction with another star during its 4.6B year history. Work from information about stellar density and differential velocity at our present (and presumably past) galactic radial location, not from the apparent fact that we have NOT suffered such an encounter. You will also need to work out how close an approach needs to be to be disruptive. (Hint, if Jupiter suffered a major change in its orbit, it would probably disrupt everything else).
2. The Kepler mission has revealed that planets are everywhere. The statistics suggest that that most, if not all stars in the galactic disk host planetary systems. Our system has one planet suitable for life-as-we-know-it, and two near misses (Mars and Venus). The presence of these two near-misses in addition to Earth suggests that life-suitable planets may not be that rare. So suppose that one in 100 stellar systems in our galaxy (most of which are dwarfs with a lifetime as long or longer than our sun) hosts a life-suitable planet. Life seems to have appear on earth as soon as it was habitable (i.e. very quickly in geological terms,) and has stuck around for a long time. Thus it seems a good bet that life-suitable planets will host life. Complex multicellular life took a long time to show up - about 3/4 of our planet's history, but it has stuck around for half a billion years, indicating it is a stable phenomenon once it arises. Technological civilization took even longer to show up - 500M years after complex organisms, and we have no positive evidence that it is stable on geological time scales. It does not seem to have happened before on this planet, so it might be a very rare event universally, even given complex lifeforms.

But suppose that life-suitable planets do eventually tend to spit out a technological intelligence, on a time scale of about 5B years (taking the one example we have). Under these assumptions, how often (on average) does our galaxy generate a technological civilization?

3. If technological civilization is persistent for periods of even several thousand years, it seems possible to physically bridge the gap between neighboring stellar systems using reasonable extrapolations of known technology (i.e. we could probably get a probe going on order of 1 million miles per hours, or about 1/1000 the speed of light). If such a technological diaspora were ever initiated, moving from star to star, with a reasonable amount of time to build the infrastructure needed to launch the next step (probably < 1000 years, given our experience on this planet), how long would it take for technology to spread across the galaxy? How does this compare to geological/galactic time scales? What does the answer suggest about galactic empires of the sort envisioned in "Star Wars" and a thousand other space operas?
4. Bonus
Are there fundamental physical limitations you know of that, assuming a power source, would prevent a suitably designed computer system employing existing technology from operating for 10,000 years in outer space? (It's away from glaciers, erosion, volcanoes, corrosion, people etc. but exposed to cold, vacuum, cosmic radiation etc..)