

53rd IAA SYMPOSIUM ON THE SEARCH FOR EXTRATERRESTRIAL INTELLIGENCE (SETI) –
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THE WASTE SCALE OF CIVILIZATIONAL DEVELOPMENT

Abstract

The Kardashev scale [1] focused on the inevitability of free energy use by any extraterrestrial civilization (ETC) and is still a robust guide in the search [2]. However, this focus on free energy has neglected the inevitability of its thermodynamic counterpart: waste production. Indeed, to maintain their existence far-from-thermodynamic equilibrium, all living and quasi-living systems (e.g. cities, nations) not only extract free energy from their environment, but also inevitably produce waste, in the form of degraded material or heat.

Inspired by the Kardashev's scale, we introduce the waste scale of civilizational development, and its associated types (see also [3]). Type I is planetary and keeps most of its waste products inside the boundary of the planet. This is our current level. Type I.1 and type I.2 generate waste respectively in the orbit of the planet, or within the planetary system. Although we have waste in orbit, and have left some trash on solar system bodies, these are largely unintentional and unwanted, and not part of a waste management policy. The next level is a Type II civilization that cares about keeping its whole stellar system clean, and thereby rejects waste outside the home star's gravitational bound. We add Type III civilizations where the waste and entropy leave the gravitational bound of the host galaxy. The most speculative Type IV civilizations would manage to make waste leave the space-time region that defines our universe - although this latest level may not be necessary as the expansion of the universe itself is a growing sink for entropy, that enables local order to emerge ([4], [5]).

We illustrate the waste scale with existing search strategies in technosignature searches, from exoplanetary pollutants, to Dyson spheres and stellivores, and discuss broader implications. Focusing on the production and management of waste is a fundamental strategy to model and anticipate the signature of any ETC. It is complementary to the search for free energy use, and the search for interstellar signals.

References

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