Kardashev Civilizations: Probability, Spacing, Delta-v, and Observability

1. From 1 per 100 Trillion Planets to a Rough Spacing

We assume a probability of 1 Kardashev civilization per 10^{14} suitable planets. In a Milky Way–like galaxy with $\sim 10^{11}$ stars and $\sim 10^{10}$ suitable planets, the expected number of Kardashev civilizations is:

$N_{civ} \approx 10^{10} \times 10^{-14} = 10^{-4}$

This implies 1 Kardashev civilization per 10,000 galaxies. Given typical galaxy spacing of 1–3 million light-years, the average distance between such civilizations is estimated to be 10–30 million light-years.

2. Delta-v / Speed Implied by That Spacing

Assuming a cruise fraction f of the speed of light (c), and a distance $D \approx 10^7$ light-years:

Travel time $T \approx D / (f \times c) = 10^7 / f$ years

Even with near-relativistic speeds (f = 0.1 to 0.9), travel times range from 10^7 to 10^8 years. This makes physical contact infeasible due to light-speed limits and civilizational coherence times.

3. Does Going Type II or III Fix Observability / Interactability?

Type I (Planetary-scale)

Energy use: $\sim 10^{16}$–10^{17} W. EM leakage is weak and short-lived. Detection range: tens to hundreds of light-years. Travel limited to local system and nearest stars.

Type II (Stellar-scale)

Dyson-like structures and directed energy systems enable beamed propulsion and megastructure signatures. Observable across the galaxy and possibly intergalactic distances. Still limited by light-speed for physical travel.

Type III (Galactic-scale)

Energy use: $\sim 10^{37}$–10^{38} W. Galaxy-scale engineering yields unmistakable signatures. Observable across hundreds of millions of light-years. Physical interaction remains constrained by light-speed.

4. Probability That a Kardashev Civ Reaches Type II or III

Let $P_{K1} \approx 10^{-14}$ (Type I civ per suitable planet)
Assume:
$P_{K2|K1} \approx 10^{-2} \rightarrow P_{K2} \approx 10^{-16}$
$P_{K3|K2} \approx 10^{-2} \rightarrow P_{K3} \approx 10^{-18}$
Thus:
- Type I: 1 per 10^{14} suitable planets
- Type II: 1 per 10^{16} suitable planets
- Type III: 1 per 10^{18} suitable planets

This implies Type II civs are separated by hundreds of millions of light-years, and Type III by gigaparsecs.

5. Summary: Do Higher Types Alleviate Restrictions?

Type I: Locally observable, limited to nearby stars.
Type II: Observable across galaxies, but still limited in physical interaction.
Type III: Observable across the universe, but interaction remains constrained by light-speed.
Conclusion: Higher types improve observability but do not overcome the fundamental delta-v and time barriers for interaction.