Searching for Extraterrestrial Intelligence Beyond the Milky Way

*The first Swedish SETI project*

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Searching for Extraterrestrial Intelligence (SETI) – A Brief History

- 1959 – Cocconi & Morrison (Nature): “Try the hydrogen frequency (1.42 GHz)”
- 1960 – Project Ozma
- 1977 – The Wow signal
Searching for Extraterrestrial Intelligence (SETI) – A Brief History II

- 1984 – The SETI Institute
- Late 1990s – Optical SETI becomes popular
- 1999 – SETI@home
- 2007 – Allen Telescope Array
- 2012 – SETI Live
The Fermi Paradox

• No signals from E.T. despite 50 years of SETI
• The Milky Way can be colonized in \(~1\%\) of its current age – why are we not already colonized?
• *Where is everybody?*

50+ possible solutions are known (e.g. Brin 1983, Webb 2002)
A Few Possible Explanations

• Everybody is staying at home and nobody is transmitting
  – Virtual worlds more exciting than space exploration?
  – Berserkers → Transmission = Doom

• Wrong search strategy
  – Try artefacts, Bracewell probes, IR laser, internet, DNA, Dyson spheres...

• Intelligent life is extremely rare
  – Try extragalactic SETI
Beyond the Milky Way

• Carl Sagan: ”More stars in the Universe than grains of sand on all the beaches on Earth”

• Stars in Milky Way $\sim 10^{11}$

• Stars in observable Universe $\sim 10^{23}$

Only a handful of extragalactic SETI projects carried out so far!
Millenium simulation + Semi-analytic galaxy models + Metallicity-dependent planet formation → The typical Earth-like planet in the local Universe is ≈ 3 Gyr older than Earth!

Erik Zackrisson, Anders Johansen, Juan González (2014, in prep.)
Earth-like planets in a cosmological context II

Earth-like planets around Solar-type stars in the observable Universe: $\sim 10^{18}$

Comparable to grains of sand on the longest beach in Sweden!

Laholmsbuktens strand – the longest beach in Sweden (12 km)
Supercivilizations – The Kardashev scale

• Based on the amount of energy that a civilization is able to harness

• Kardashev (1964): Type I, II & III

Nicolai Kardashev
Kardashev type I, II, III

Power consumption:

Type I  Similar to the Solar insolation on Earth ($\sim 10^{17} \text{ W}$)

Type II Similar to the luminosity of their parent star ($\sim 10^{26} \text{ W for the Sun}$)

Type III Similar to the luminosity of their home galaxy ($\sim 10^{37} \text{ W for the Milky Way}$)
The Dyson Sphere

Dimensions envisioned for a Solar system
Dyson sphere made by disassembled planets

Freeman Dyson
Dyson ring

Dyson swarm

Dyson bubble
Hunting for Kardashev type III

The Tully-Fisher relation

Galactic-scale colonization using Dyson sphere → Mass unaffected but diminished UV/optical luminosity

Very few disk galaxies deviate from the Tully-Fisher relation → *Kardashev type IIIs must be rare* (Annis 1999)
The largest extragalactic SETI project so far!

Per Calissendorff (2013, BSc thesis, SU)
Erik Zackrisson, Per Calissendorff, Saghar Asadi (2014, in prep.)
But what are the outliers?

Example I: Edge-on disk incorrectly assigned a lower inclination
But what are the outliers?

Example II: Two interacting (?) disks incorrectly classified as one object
Colonization using Dyson spheres

Per Calissendorff (2013)
Colonization using Dyson spheres

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Colonization using Dyson spheres

Per Calissendorff (2013)
Complications

- Colonization using Dyson spheres
  - Modified surface brightness profile
  - Misinterpreted axial ratios
- Object not classified as disk galaxy and never enters Tully-Fisher sample?
Summary

• Largest extragalactic Dysonian SETI project yet
• Star-fed Kardashev type III civilizations extremely rare in disk galaxies (<0.5%)
• Some KIII candidates are clearly due to failed measurements or misclassifications
• What are the others? We don’t know yet...