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Archaeology and direct imaging of exoplanets

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Abstract. The search for extraterrestrial technology effectively began 45 years ago with Frank Drake's Project Ozma and a radioastronomy start to the search for extraterrestrial intelligence (SETI). Eventually searches began for possible interstellar probes in stable orbits in the Solar System, as well as for infrared excesses from possible Dyson spheres round Sun-like stars. Whilst the Cold War was still underway, some scientists looked for evidence of nuclear waste dumps and nuclear wars elsewhere in the Milky Way. None of this work was carried out by archaeologists, even though by their very nature archaeologists are experts in the detection of ancient technologies. The technologies being searched for would have been partly ancient in age though advanced in techniques and science. The development of ESA's Darwin and NASA's TPF for detection and imaging of Earth-like exoplanets in our galactic neighbourhood represents an opportunity for the testing of techniques for detecting signatures of technological activities. Ideally, both Darwin and TPF might be able to provide spectroscopic data on the chemistry and biochemistry of the atmospheres of Earth-like exoplanets, and thus to detect some of the signs of life. If this can be accomplished successfully, then in theory evidence for pollution and nuclear accidents and wars should be detectable. Some infrared signatures of ETT on or round exoplanets might be detectable. Direct visual imaging of ETT structures will probably not be feasible till we have extremely powerful interstellar telescopes or actually send orbital craft.

Keywords. Search for extraterrestrial technology (SETT), Exoplanets, Archaeology, Pollution, Infrared.

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1. Archaeology and exoplanets

Archaeology is the scientific study of the physical evidence for human and proto-human behaviour and evolution from the early Palaeolithic of 2.6 My in Africa to modern forensic archaeology and space heritage (Campbell 2004; Gorman 2005). Archaeology could be the study of the evolution, technology, society and impact of any intelligent species or intelligence in the Universe (Campbell 2004). It is limited at any given time by what is feasible.

The scientific search for extraterrestrial intelligence (SETI) began 45 years ago with the work of Frank Drake (see Tarter 2001; Ekers *et al.* 2002). Some SETI research also involved at times a search for other signs of extraterrestrial technology (Shostak 1998; Ekers *et al.* 2002). Having been negatively influenced by the efforts of popular authors like Erich Von Daniken in the 1970s and subsequently to discredit Earth-based ingenuity and to claim that all of Earth's ancient civilizations owe their origins to one form or another of extraterrestrial visitor, most professional archaeologists have avoided widening their associations with the space sciences, other than satellite imaging of Earth and studies in archaeoastronomy, namely studies of ancient or traditional naked-eye observations of the sky as recorded in texts, represented in monuments, represented in rock art or recorded by ethnographers, archaeologists or astronomers working with living Indigenous peoples (see Ruggles and Campbell In Prep.). I prefer the acronym SETT (search for extraterrestrial technology) to SETA (search for extraterrestrial artefacts) as the latter term has been fully adopted by those like Von Daniken who believe that alien artifacts and influences are present nearly everywhere on Earth.

For radioastronomers working in SETI, the intelligence of a technologically capable species elsewhere in the Milky Way is basically indicated by the ability to control radio waves and/or to fire pulsed laser beams. However, defining intelligence in a broader way is also problematic. The social and behavioural science disciplines which look at intelligence in humans have never come to a full agreement on how to define intelligence. Further, as scientists we can not agree on whether certain other Primates (in particular chimpanzees and bonobos), certain species of Cetaceans (especially certain dolphin species), some birds (e.g. New Caledonian crows which invent and construct tools) and some Molluscs (particularly cephalopods, e.g. laboratory-confined octopus which open locks, steal crabs and then hide the evidence of what they have done) are intelligent. The relevance of detecting and understanding intelligence in other Earth-bound species is enormous. If we can not manage it here, how will we be able to recognize and understand a signal from ETI, other than saying we have found a carrier beam. The issues of communication and understanding in interstellar message construction are being addressed by workshops and conferences organized by Doug Vakoch of the SETI Institute (http://www.seti.org).

Now that more than 155 exoplanets (primarily gas giants) have been detected, and the technology is being developed to detect and image smaller Earth-like exoplanets (ESA's Darwin, NASA's TPF etc), it is time for archaeology to reconsider its inactive roles in astronomy and astrobiology (on the latter, see Chyba and Hand 2005).

Thus far the search for astroengineering structures like Dyson spheres and Dyson rings has been unsuccessful (Shostak 1998; Ekers *et al.* 2002). Equally, the search for extraterrestrial probes which might have been positioned at certain Lagrange points or placed in special orbits in the Solar System has been unsuccessful (with the possible exception of the object catalogued as 1991 VG and in heliocentric orbit near Earth, see Steel 1995). Does this then automatically mean that the answer to Enrico Fermi's paradox ("Where is everybody?") is zero, or rather n = 1, the "1" being us, the only intelligent species in the Milky Way, as Ward and Brownlee (2000) and Morris (2003) would have it. Fermi's paradox is more of a puzzle than a paradox, but in any event I do not think we can answer it fully as yet. It is also particularly anthropocentric. For what are supposedly "fifty solutions" to it, see Webb (2002) and for critiques of the reasoning behind Fermi's Paradox, as well as behind Earth-centred astrobiology generally, see Cohen and Stewart (2004). I would argue that our instruments and search strategies have been inadequate, and that they have not allowed for a sufficiently wide range of options or possibilities. Further, many of the earlier searches for extrasolar technology were done during the paranoia of the Cold War and before the current observations and hypotheses on the Universe had been developed (e.g. see Gott 2002). The various sorts of interference, distortion and outright blockage of line of sight detection which are now conceivable are much greater than 20 or 30 years ago. Have there in fact been no signs of extrasolar nuclear accidents, nuclear wars or stellar dumping of nuclear waste in the Milky Way, as it would seem, or have we missed the evidence? I think one can argue for the latter, that is, the evidence could exist but so far we have been unsuccessful in detecting it. It might also still be impossible or highly unlikely for us to be able to detect or recognize a highly advanced civilization (a view espoused early on for example by Freitas 1983; on the so-called "Interdict Hypothesis", see Fogg 1987).

The situation could change with the development of ESA's Darwin, NASA's TPF (Terrestrial Planet Finder) and other space-based telescopes which might be designed, launched and parked at L2 in the Earth-Sun system or elsewhere. If the chemistry and biochemistry of Earth-like exoplanets possibly in orbit round some 492 stars within 25 pc can be detected and analysed (Kaltenegger *et al.* this volume, a), then in theory we could detect some signs of possible technologies (pollution, "greenhouse" effects, infrared excess, variable ozone levels, nuclear accidents or wars etc). On Earth we can distinguish between natural and artificial pollution, although there is an overlap in the characteristics. Our own impact or influence on the creation of a "greenhouse" event is becoming more clearly established, though there are ongoing debates on what is evidence for a natural climate cycle and what is evidence for human interference with nature. The mass rate of extinctions has gone up so much, and is continuing to climb, that future palaeontologists looking back on the present time will possibly interpret it as equal to the K/T boundary event (the Cretaceous/Tertiary boundary extinction of the dinosaurs and many other forms of life at about 65 My). There might eventually be an argument for shifting the boundary of the Holocene/Pleistocene to the present, as the total extinctions will vastly outnumber the extinctions which occurred at the end of the Pleistocene as currently defined (11 Ky).

From archaeological and SETT points of view the development of instruments and software for the direct imaging of exoplanets should allow for detection and analysis of chemical, biochemical and radioactive traces of technological activity (cf. Kaltenegger *et al.* this volume, b), Both Earth-like planets and other exoplanets and portions of targeted star systems should be surveyed. Traces of technological activity (e.g. massive mining) could occur either on Earth-like planets or on other bodies such as asteroids and rocky moons. Massive use of ice and water might also be detected, as might variations of the concept of Dyson spheres and rings. We should also search beyond the galactic habitable zone (cf. Lineweaver *et al.* 2004; Campbell 2004). Eventually, we might investigate some of the neighbouring star systems literally directly with multigeneration spacecraft (Kondo *et al.* 2003).

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