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A search for 'frozen optical messages' from extraterrestrial civilizations

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Abstract: For a quarter of a century we have been engaged in a systematic examination of high-quality photographic (optical) sky surveys in the search for new celestial bodies of various kinds. It took about 5000 hours to cover the whole northern celestial hemisphere and half of the southern one. In total, about 12000 new objects were discovered. From the very beginning of our programme we also searched for objects (or groupings of them) of rather peculiar morphology. The motivation was to detect objects revealing exceptional physical processes, on the one hand, but also to discover constructions possibly created by advanced extraterrestrial civilizations (ETCs), on the other hand. A number of very peculiar objects were indeed found (these were mostly studied in detail later), but none of these appeared likely to be the product of alien masterminds. We may conclude that at least within about 10000–20000 light-years around the Solar system no highly advanced ETCs intend to reveal themselves through such objects.

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Introduction

Optical sky surveys play a significant role in astronomy. Their importance is obvious: most stars have surface temperatures ranging from a few thousand to 10000–15000 K (Sun, ~ 6000 K) and their radiation can be calculated from black-body emission. Hence, a major part or most of their light is emitted within the optical range of the electromagnetic spectrum. Systems consisting of and/or heated by stars, such as, for example, stellar clusters, most galaxies, and circum- and interstellar nebulae will thus be best observable in the optical wave range.

Optical sky surveys are useful mainly for two reasons: for searches for hitherto unregistered objects, and as a basis for supplementing data obtained in other wavelength regimes. The first great optical sky survey of high and uniform quality, penetrating much deeper than any previous survey, was the Palomar Observatory Sky Survey (POSS I) taken from 1949 to 1958 with the 48 in Schmidt telescope on Palomar Mountain, California. A series of 936 different fields that covered the entire sky above a declination of $-33°$ were photographed in red and blue light, respectively (Minkowski & Abell 1963; Lund & Dixon 1973). This excellent atlas is still in use. The same telescope was used for the 'Second Palomar Sky Survey' (POSS II), begun in the 1980s and finished around the turn of the millennium, with an even deeper limiting magnitude (e.g. $B = 22.5$ mag and $R = 20.8$ mag compared with 21.1 and 20.0 mag for POSS I, respectively) and a better resolution owing to the use of finer-grain emulsions (Reid *et al.* 1991). In recent decades optical sky surveys of comparable quality and deepness have also been undertaken for the southern sky, in particular the ESO (European Southern Observatory) atlas and the SERC (Science and Engineering Research Council of Great Britain) atlas.

The amount of information in these optical sky surveys is enormous. On POSS I ~ 10^9 stars, at least ~ 10^8 galaxies as well as other objects of various kinds in vast numbers are visible. Clearly, all of these surveys have been used extensively from the very beginning and a number of searches for particular types of objects have been undertaken examining copies of them on paper prints, glass or film. To our knowledge none of these surveys has ever been devoted to a search for signs from extraterrestrial civilizations (ETCs).

Our searches

In 1977, members of our department (J. Dengel, H. Hartl and R. Weinberger) began a thorough examination of all the fields of the famous POSS I. Our prime motive then was to search for new planetary nebulae of low surface brightness, but from the very beginning, non-stellar objects of various other kinds (except ordinary-looking galaxies and most asteroid trails) if suspected of being new, were also registered. In addition, we always paid considerable attention to highly unusual, and above all unique, 'unnatural'-looking objects or groupings of objects, such as nebulae with hitherto unseen structures, extragalactic systems with outstanding features, chains or rings and ellipses of stars, etc. All of the 936 POSS I fields were searched; about half of them were examined independently by three persons and three-quarters by two persons. The POSS I project included a number of follow-up studies and was completed about 10 years ago. Examples of the results of our searches can be found in Dengel *et al*. (1980), Weinberger (1980), Auner *et al*. (1983) and Hartl & Weinberger (1987).

Parallel to this 'planetary nebulae' project on POSS I, and also later, several other searches for planetary nebulae in the southern part of the southern hemisphere were also carried out by us on film copies of the ESO/SERC surveys, and for galaxies beyond the plane of the Milky Way on prints of the POSS I and, in the 1990s, on film copies of its successor, POSS II (e.g. Melmer & Weinberger 1990; Seeberger *et al*. 1996; Weinberger *et al*. 1999). Nowadays, copies of POSS II are still used by us when searching for particular objects such as overlapping pairs of galaxies (for later studies of their halos).

The search method applied by us has remained the same over the years: the prints or films were examined with the naked eye supplemented by examinations with magnifying glasses (8 ×) to find extended objects of extremely low surface brightness. The total time devoted to these search projects (with the POSS I search being the most time consuming) amounted to more than 5000 h.

All told, our 25 years of searching were rewarded with more than 12000 new objects, the vast majority of which are galaxies shining through the dust in the plane of the Milky Way, about 130 are planetary nebulae (a total of 1500 are known in our Galaxy). Furthermore, we found several comets, a dozen or so asteroid tracks at unusually high ecliptic latitudes, a dozen star clusters, several peculiar examples of interacting galaxies, and a few sources that look unique (among them, for example, a nebula consisting of curious criss-crossing filaments (Zanin & Weinberger 1997)).

Constructions by extraterrestrial civilizations?

Unfortunately, no example of a strikingly 'unnatural'-looking object or grouping of objects was found during our 25 year long surveys, although we never lost sight of this aspect while engaged in all of these searches.

We were, and still are, well aware that there are arguments which support looking for signals from ETCs (if any exist) in wavelength regions other than the optical, such as the radio regime with its 21 cm hydrogen line or other lines. The SETI project is an excellent example of this (Wilson 2001). Neither would we have been able to detect, say, short optical pulses as carriers of information, since these would be smeared out, i.e. not be resolvable due to the exposure times of 45–60 min for most of the (red-sensitive) POSS I plates.

In principle, overwhelmingly 'strange', 'unnatural'-looking luminous optical objects and/or groupings of objects could only have been constructed by ETCs of Kardashev types II and III, i.e. civilizations that are technologically far more advanced than our own (Kardashev 1964).

Manipulating, say, the energy of a nearby star (let us, for example, assume that an alien civilization resides on a planet around a star which is, in fact, a component of a wide binary stellar system, where the second star's gravity or radiation is not a great disturbing factor) or particularly collecting stars of equal spectral type and forcing them into a certain configuration would be extremely energy consuming. All of these arguments – especially the latter – may be used to state that searches such as those undertaken by us should *a priori* be fruitless, even if such highly advanced ETCs were to exist at not too great a distance.

Patterns of thought and motivation might, however, be completely different from ours. Apart from that, sending signals such as those SETI supporters are longing for is a process which could possibly be restricted to a certain time span: perhaps those with the political say on an alien planet have at some time formulated and realized the plan to send signals, but the next government might simply decide to switch them off. However, manipulating a nearby companion star, for example, by letting it eject a mighty gaseous jet with numerous luminous knots embedded in it, the emissions of which could actually represent the information itself (like smoke signals!), may have proved very demanding and it may be difficult to switch such signals off. Above all, such a phenomenon could be visible over large distances and, more importantly, by calculating the ejection velocities of natural jets astronomers nowadays know that such a jet can have a lifespan of several thousand years. In other words, an information-carrying phenomenon of this kind would not be transient as tends to be the nature of signals, but would represent a long-lasting 'frozen' message.

A jet, on the other hand, has the disadvantage that it would be most clearly visible at an angle of 90°. Hence, a more or less spherically symmetric ejection process from a companion star (which would, however, require protection for the ETC's planet) would be far more advantageous since it can be seen from all directions. What we mean by this can be demonstrated by means of an image of the planetary nebula IC 418 (Fig. 1). This expanding gaseous bubble around an evolved star (the 'Spirograph' Nebula; distance about 2000 light-years) shows a wealth of intricate, roughly regularly distributed filaments or knots. Could they not have been arranged to contain a message? If so, it would again be a non-transient 'frozen' optical message since it would be visible over a period of many thousand years. A Kardashev 'type II' ETC could manage such a construction.

As to a Kardashev 'type III' civilization, which can exploit the resources offered by its home galaxy, we can be much more imaginative. What about a very special, highly 'unnatural' grouping of stars, say stars of the same brightness (and mass), orbiting a massive central source (a black hole perhaps) with the same relative distances between the stars? A system of this type would be clear proof that aliens have been at work. However, even an extremely advanced ETC would probably not have infinite energy resources at its disposal, i.e. it would have to collect stars which are very frequent on the one hand but sufficiently luminous on the other. Stars more or less like our Sun (spectral type F to G) would be a good choice: they are not underluminous (like the numerous red stars of type K and M), have a reasonable space density and the mere fact that

Fig. 1. An image of the planetary nebula IC 418 taken with the Hubble Space Telescope (http://heritage.stsci.edu/public/2000sept7/ic418big.html). Image credit: NASA and The Hubble Heritage Team (STScI/AURA). Could a highly complex network of filaments and knots such as this represent a frozen message? It is visible from all sides over a distance of several thousand light-years and also over a period of several thousand years. The high resolution of this image is not attainable with existing photographic optical sky surveys, but requires the Hubble Space Telescope (0.1 arcsec resolution) or a ground-based telescope with comparable resolution power.

they retain a rather constant luminosity over about 10^{10} years shows such stars to be *a priori* interesting candidates for life seekers. With the plate material at our disposal we could hardly have missed a conspicuous ring (or ellipse or sphere, etc.) composed of such stars, provided a grouping of this kind had an apparent size of greater than ~ 1 arcmin.

Let us assume that each of these member stars has an apparent visual magnitude of $V = 18$, an absolute magnitude of $M(V) = +4.5$, and that there is negligible interstellar dust extinction between us and the grouping, then a distance of $D = 16\,000$ light-years results (cf. the optical diameter of the Milky Way is 100 000 light-years). For a jet or a spherical bubble containing luminous knots and/or filaments as described above, a similar distance limit can be attained (with the Hubble Space Telescope; the knots themselves could not be resolved at the resolution of POSS I or POSS II). The distance limit could be considerably extended to millions or dozens of million light-years if an ETC could manage to mark a whole galaxy, but we had better not slip into pure science fiction. Nevertheless, galaxies with highly peculiar morphological properties were found by us during our searches, and will be investigated in detail in the years to come. Given the tremendous complexity in morphology among extragalactic systems, however, we expect to be able to enrich the galactic zoo by a few outstanding examples rather than by having found signs of extremely advanced civilizations.

Hence, 'frozen optical messages' from aliens may possibly exist, but have not been discovered by us in the quarter of a century that we have spent searching through optical sky surveys. This negative result appears to support the conclusions drawn by the authors of the book entitled *Rare Earth. Why Complex Life is Uncommon in the Universe* (Ward & Brownlee 2000).

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