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ABOUT COMMUNICATION BETWEEN CIVILIZATIONS BY SUPER-SUPERGIANTS RETRANSLATION

G.M. Beskin, A.V. Sannikov
Special Astrophysical Observatory of the Russian AS,
Nizhnij Arkhyz, 357147, Russia

ABSTRACT. *A method of communication between extraterrestrial civilizations which elaborates upon the strategy of convergence (Makovetsky, 1981) is proposed. Super-supergiants, which are rather rare (100-200 in the Galaxy) and astrophysically interesting can be expected to attract the attention of advanced civilizations. Therefore they may be the points of convergence for information exchange. In particular the super-supergiants may play the functions of re-translators, converting directed radiation having a quantum energy of 50 keV into isotropic radiation. Assuming a receiving capability similar to ours, this implies that the transmitter power should be about* $10^{-4}L_{\odot}$.

1. The possibility for an ETI (Extra-Terrestrial Intelligence) to communicate its existence using a re-translator, able to disperse isotropically sharply beamed radiation which is aimed in its direction, is discussed. Isotropic reflection is necessary for the equal probability of receiving a signal from every direction at least within the solid angle 2π. The super-supergiants, stars with enormous mass and luminosity, could be used as such re-translators. These stars are relatively rare (de Jager, 1980), and as the brightest they must attract attention of possible ETI. These stars as well as other unique objects, pulsars, X-ray sources, etc. are the convergence points.

2. The scheme of a hypothetical contact is shown in Fig.1.
The necessary conditions to realize this contact are as follows:

a) The laser beam divergence at the distance r_1 should be less than the star radius R when the beam reaches the star:

$$\alpha < (R/R_{\odot}) \cdot (1\mathrm{kpc}/r_1) \cdot 10^{-5}\mathrm{arcsec}.$$

We obtain $\alpha \sim 10^{-5}$ arcsec for $R = 10\ R_{\odot}$, $r_1 = 10$ kpc, which may be achievable in the near future;

b) The scattering of an incoming beam must be isotropic;

c) The incoming beam power and the albedo of the star (the reflected fraction of the beam radiation) must be such that the ETI-R receiver would be sensitive enough to detect a signal.

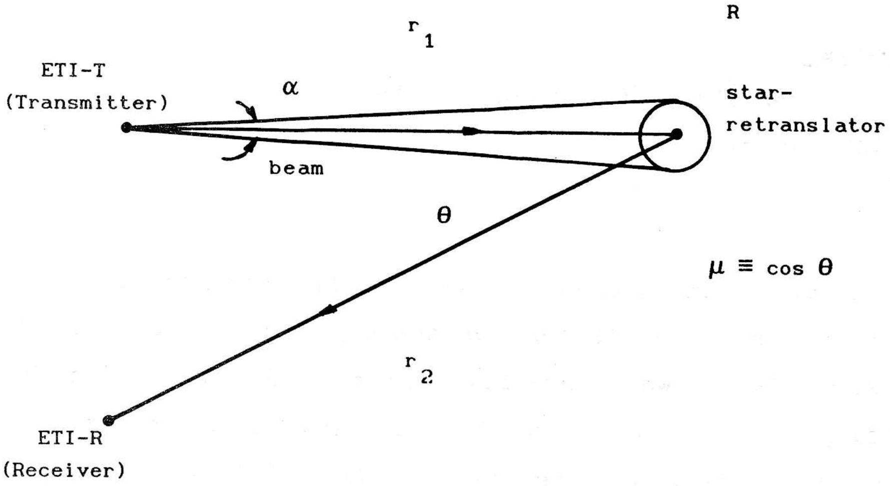

Fig. 1.

3. An energy range of about 50 keV of incoming photons is satisfactory for the condition (c). The scattering occurs only in the star's atmosphere, where the density is about 10^{-7}-10^{-8}g/cm^3. Here the absorption caused by the photoelectric effect almost vanishes for photons with these energies. The absorption creating the e^-e^+ pairs is also absent. We need consider only one type of interaction, namely Compton scattering (Basko and Sunyaev, 1974).

Table 1 presents the fractions of P_1 and P_2 photons (relative to incident) which are scattered one or two times in the stellar atmosphere, respectively. These quantities were calculated assuming a planar atmosphere, $\mu_0 = \cos\theta_0$, where θ_0 is the angle of incidence of the incoming beam. A_p is the planar albedo of a thick atmosphere (Sobolev, 1956) with $\lambda = 1-h\nu/mc^2 \simeq 0.9$ ($h\nu/mc^2$ is the fraction of the photon energy which it yields, so this expression is true if $h\nu \ll mc^2$).
The expressions for P_1 and P_2 are

$$P_1 = \frac{1}{2}\left(1 - \mu_0 \ln\frac{1+\mu_0}{\mu_0}\right);$$

$$P_2 = \frac{\mu_0}{4}\left(1 - \mu_0 \ln \frac{1+\mu_0}{\mu_0}\right) \ln \frac{1+\mu_0}{\mu_0} + \frac{1}{4}\int_0^1 \frac{\mu^2}{\mu+\mu_0} \ln \frac{1+\mu}{\mu}\, d\mu.$$

Thus, approximately 30-40% of the photons falling on the star come out after one r two scatterings.

Table 1.

μ_0	P_1	P_2	A_p
0.0	0.50	0.10	0.68
0.5	0.23	0.12	0.51
1.0	0.16	0.09	0.41

4. We may suppose Compton scattering to be more or less isotropic because hν, kT ≪ c^2 (T = 50000 K corresponds to 5 eV). As follows from Table 1, about half of the eturning photons are scattered only once, so we assume with satisfactory accuracy hat every small area of the star surface scatters incoming photons quite isotropially. Then we obtain the following expression for the flux density $H(r_2, \mu)$ of the eflected radiation:

$$H(r_2,\mu) = \frac{N}{2\pi r_2^2} \int_0^{\sqrt{1-\mu^2}} \mu_0 A_p(\mu_0) \frac{2}{\pi} \arccos\left(\frac{\mu_0}{\sqrt{1-\mu_0^2}} \cdot \frac{\mu}{\sqrt{1-\mu^2}}\right) d\mu_0, \quad \mu < 0;$$

$$H(r_2,\mu) = A_{sph} \frac{N}{2\pi r_2^2} - H(r_2,-\mu), \quad \mu > 0,$$

here N is the beam power, A_{sph} is the spherical albedo of the star (A_{sph} = 0.48 if =0.9 (Sobolev, 1956). The directional diagram is shown in Fig. 2.

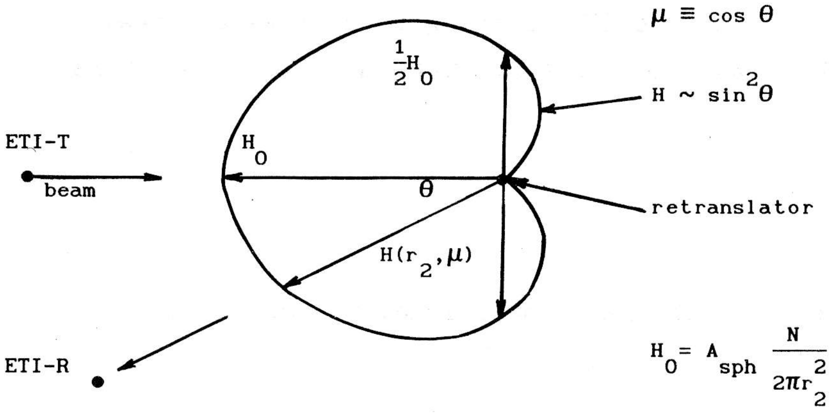

Fig. 2.

It can be seen that the maximum flux density H_0 is directed back toward the incoming laser beam and even at the angle $\pi/2$ it makes half of maximum, so the scattering into the solid angle 2π is quite isotropic.

5. An estimate of signal delay in the stellar atmosphere as well as the blurring of the pulse can be obtained as $\Delta t \ll 2R/c$. Therefore, the blurring of the pulse width is determined by the geometric size of the star. Thus the value $2R/c$ is a restriction on the temporal structure of the signal. At a higher frequency of pulses they begin to overlap each other after the re-translation, and the amplitude of the useful signal decreases.

6. In order that the signal could be detectable within solid angle 2π it is needed that

$$\frac{1}{2} H_0 > H_{lim},$$

where H_{lim} is the sensitivity limit of ETI-R receivers; or

$$\frac{N}{H_{lim}} > 2.5\cdot10^{44}\left(\frac{r_2}{1\text{kpc}}\right)^2 \text{cm}^2.$$

For a typical distance r_2 = 1 kpc and a current sensitivity for X-ray telelescope $H_{lim} \sim 10^{-14}$-10^{-15} erg/sec·cm^2 the power N is estimated to be

$$N > 2.5\cdot10^{29}\text{erg/s} \sim 10^{-4} L_{\odot} \;.$$

Such value for N will not affect sufficiently the processes in the considered star ($L \sim 10^6\ L_{\odot}$).

7. The laser power will decrease with increase in instrument sensitivity. But N must not be much less than the target star's luminosity within the range 20 - 50 keV.

As a rule, high-luminosity stars radiate X-rays ($L_x < 10^{33}$ erg/s within 0.2-4.0 keV, (de Jager, 1980)). Therefore, if the ETI wishes to send a signal, it needs a star of as low X-ray luminosity as possible. The suitable stars for us might be ζ Ori (r_1= 468 pc, T_e= 29910 K), ε Ori (457 pc, 24820 K), (de Jager, 1980). We have no information on their X-ray radiation. If the ETI is going to receive a signal, it has to be able to observe both weak X-ray stars and slightly more intense stars among stars of high luminosity.

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