for optical photons. In fact, if account is taken of absorption by interstellar matter, the star is scarcely detectable in the optical band.

It is interesting to compute the unattenuated power which one could expect to receive on the surface of the Earth in the radiofrequency band, above the cut-off frequency ν_1. For $\nu = 10^{10}$ sec^{-1}, one has $\Delta p = 10^{-18}$ W m^{-2} (c/s)$^{-1}$. This is a very high figure indeed. However, these waves would be strongly attenuated in regions of the electron cloud, where the densities are higher than the average calculated. In spite of this fact it would be interesting to observe X-ray emitters in the centimetre band of radio frequencies.

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SPACE SCIENCE

An Effect of Nuclear-reactor Operation in Space

THERE is considerable development effort towards producing nuclear reactors for SNAP (systems for nuclear auxiliary power) applications. Obviously the performance of these reactors in the space environment is a matter of some concern.

Both the effect of the reactor system on the space environment and the effect of the space environment on the reactor system should be carefully considered. Recently it was pointed out that a nuclear reactor could have a definite effect on its environment while orbiting in the geomagnetosphere[1]; now it appears that the environment can have a very definite (and unexpected) effect on the reactor system.

In particular, the photonic flux from a nuclear reactor will produce Compton electrons in nearby material. Under planetary conditions, these electrons would dissipate their energy through atomic interactions, and then return to the immediate vicinity of their origin because of electrostatic attraction. In space, however, energy dissipation is small enough to be neglected, and magnetic fields will at best cause only a small percentage of the ejected electrons to follow paths returning them to the reactor system, so electrostatic forces must play an especially large part in establishing a steady state condition. This suggests that the reactor system might achieve a noticeable positive potential while in operation. The magnitude of this effect can be determined from a few rough approximations.

Let us assume that a 1 MW (thermal) nuclear reactor is in polar orbit at an altitude of 1,000 km above the surface of the Earth. Let us further assume that the heat rejection radiator is placed about the reactor as a spherical surface. Since the radiator area would be about 120 m^2 (ref. 2), this yields a thin spherical shell (perhaps 2 cm thick) of 3·1 m radius. At the centre of the shell would be located the reactor and reflector. The reactor should be no more than 30 cm in radius (assumed spherical here), and the reflector would perhaps be 4 cm of beryllium.

It is reasonable also to assume that the average power density of the reactor is less than twice that of the power density at the reactor's edge. This provides a power density near the reactor's edge of $4·4 \times 10^{-6}$ MW/cm^3, which in turn yields a fission density of $1·36 \times 10^{11}$ fissions/cm^3-sec. Each fission can be considered to yield 7 photons at 1 MeV per photon[3].

Now 1 MeV photons have an e-folding path length in plutonium fuel of 0·7 cm, so the photon production region can be taken as $7·9 \times 10^3$ cm^3. This yields a thin shell source of $7·5 \times 10^{15}$ photons/sec (of 1 MeV each). However, geometric considerations should lower that figure to about $3·5 \times 10^{15}$ photons/sec.

The 4 cm of beryllium should attenuate the photons to approximately 2×10^{15} photons/sec. So, 2×10^{15} photons/sec (of 1 MeV each) should strike the inner wall of the radiator. If we assume the radiator to be 2 cm (of aluminium) thick, the photons/sec through the outer surface should approximate $1·4 \times 10^{15}$ photons/sec. When only those electrons within an electrons e-folding distance of the radiator's outer surface are considered, 3×10^{13} electrons/sec are Compton scattered.

If we consider further the angular spread of Compton scatter, about 5×10^{12} electrons/sec of 0·8 MeV maximum energy can be considered as ejected from the reactor system. If no other factors were considered, the reactor system would rapidly approach a positive potential of 0·8 MV. However, there are other factors which should be included.

Over the reactor's orbit, there are flux levels of trapped electrons and positive ions as low as 10^3 particles/cm^2 sec and lower[4]. The positive ions would tend to be repelled from a positively charged reactor system, while the electrons would just as effectively be attracted to the system. The large surface area of the reactor system would tend to acquire about 1×10^9 electrons/sec. This, of course, assumes the very doubtful complete repulsion of all positive ions.

We now have a Compton electron current away from the reactor system, and a trapped radiation electron current into the system. When the energy distribution of the Compton electrons is considered in light of the electrostatic build-up, a steady state potential of about 0·79 MV is found to exist on the reactor system.

The importance of this potential can be better evaluated by noting that the reactor system described would have a capacitance of $3·4 \times 10^{-10}$ farads. So the electrostatic energy stored would be 100 joules.

The discharge of 100 joules might puncture a very thin surface; but it would appear that this effect would provide merely a nuisance for the case investigated. The positive charge would tend to make objects in contact with the reactor system surface be repelled from that surface, and from each other.

However, it would seem advisable to determine the magnitude of this effect to be expected for the particular space mission planned for each nuclear reactor.

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PHYSICS

Attenuation of Shock Waves by Cooling

THE attenuation of shock waves was the subject of a recent investigation[1], where energy loss through heat transfer was suggested as the mechanism.

Experiments conducted by me[2] have illustrated that heat loss from shock waves can be an effective method of attenuation. Here, liquid nitrogen was injected into shock waves.