Theoretical Proposal for Protection of Electrical Devices of Space Probes from Interstellar Plasma by an Artificial Magnetic Field of magnetic-conducting Surface of the Circular Spacecraft

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The geomagnetic field of the Earth protects the atmosphere of the Earth from a vast proportion of incoming solar wind. In fact, it is shielded from direct solar wind to high-energy cosmic particles by the magnetosphere, which is formed by interaction between the geomagnetic field and the solar wind radiation.

When the jet of wind hits the cold material, it forms a bow shock as it slows down, like a wave breaking off the front of a boat. Slowly, it pushes the material away. Eventually, the cloud of the material stretches from its circular physique to create an outflow along its rotation axis, the axis around which the star spins [2].

The solar wind is a stream of charged particles released from the upper atmosphere of the sun. Its particle can escape the sun's gravity because of their high energy. The solar wind consists of plasma characterized by low densities ($0{\cdot}1\text{-}2 \times 10^6 m^{-3}$), moderate temperatures (10 to 300eV) and $fast/supersonic$ (300-1000$^{km}/_{s}$) directed flows, the actual solar wind output is highly variable on time scales of milliseconds upwards due to the localized and turbulent origins of the energetic plasma from the surface of the Sun. The solar magnetic field is carried with the out flowing plasma and is of the order of 2-10nT at the distance of the Earth's orbit. A bow shock generated by solar wind is shown in Fig 1. Of greatest concern from a manned spacecraft safety standpoint are the energetic (10-100 MeV) heavy solar wind particles of which ~90% are protons, 9% are alphas, with electrons making up the majority of the remaining mass [3].

Understanding the interactions between spacecraft or orbiter and space plasma becomes very important due to the potential between space vehicles and the ambient plasma of solar wind that can cause serious environmental interactions such as spacecraft anomalies due to acting, sputtering and electromagnetic interference. It is proposed to use an artificial magnetic-conducting surface for the circular spacecraft or orbiters. In this case, the ion/electron flux of the emitted plasma of solar wind, temperature of particles and density of plasma is important for making an artificial magnetic field by a magnetic surface or another methods of creating

magnetic field (like solenoid). It means that plasma wind can be shifted around and it can be prevented from lethal effects of plasma of solar storms on electrical devices of space vehicles around the Earth orbit or regions like Aurora.

Another problem is interaction of interstellar plasma and space probes. Fig.2 shows that the space is not in fact empty. It is filled with tenuous (and in some places so tenuous) plasma. This plasma is much like our atmosphere and shock waves can in fact travel through it.

When a non-plasma body such as a spacecraft or space explorer is immersed in plasmas, it is generally charged due to incoming electron and ion fluxes to the body. When the incoming electron and ion fluxes become equal and the total current to the body becomes zero, the body obtains a floating potential. The floating potential is normally negative with respect to the space potential in the isothermal plasma because electron thermal velocity is much larger than that of ions. One of the practical methods to eliminate the space plasma in the surface is the use of plasma contactor [5] in the surface of space explorers along with artificial magnetic field produced by up and down poles of the device, like Voyager 1 and 2. The electron/ion flux of the emitted plasma from interstellar plasma is an important process for neutralization by magnetic field.

As an example, shock wave that Voyager1, a space probe that was launched by NASA on September 5, 1977 to study the outer solar system [6], encountered is a “tsunami wave”. The cause is a coronal mass ejection (CME), in which the Sun heaves out a magnetic cloud of plasma from its surface, generating a pressure wave. In fact, the outgoing wave runs into charged particles in deep space-interstellar plasma-creating the disturbances. In all, Voyager1 has experienced three of these shock waves, with the most recent first being observed in February of 2014 and still continuing. The shock wave was causing the ionized interstellar gas to sign or vibrate like a bell [7]. The frequency of the waves is shown in Fig 3.

When a space explorer is immersed in magnetized plasma of interstellar wind, the body becomes negatively charged with respect to the space potential due to large thermal velocity of electrons so it makes disturbances in electrical devices of the space probes. As shown in Fig 3, space probe, Voyager 1, encountered with bow shock of interstellar wind in May 2013 and November 2014 which brought it a destructive effect on its electrical devices. At Fig. 4 we can see that this proposal would be practical in making artificial magnetic field by a magnetic surface or solenoid in space explorers like Voyager 1 and 2 along with creating to shift the path

of the incoming interstellar wind exactly like the magnetic field of the earth that protect the Earth from solar wind.

It has showed that interstellar plasma hitting to space probes, like Voyager 1 and 2, has lethal effects on electrical devices of space vehicles. It has been proposed that shifting the path of incoming plasma can be useful for protecting of space probes. Besides, it is proposed to make an artificial magnetic field by device itself, so the interstellar plasma can be turned away from the space probe which is like the interaction process of the Earth's magnetic field and solar wind.

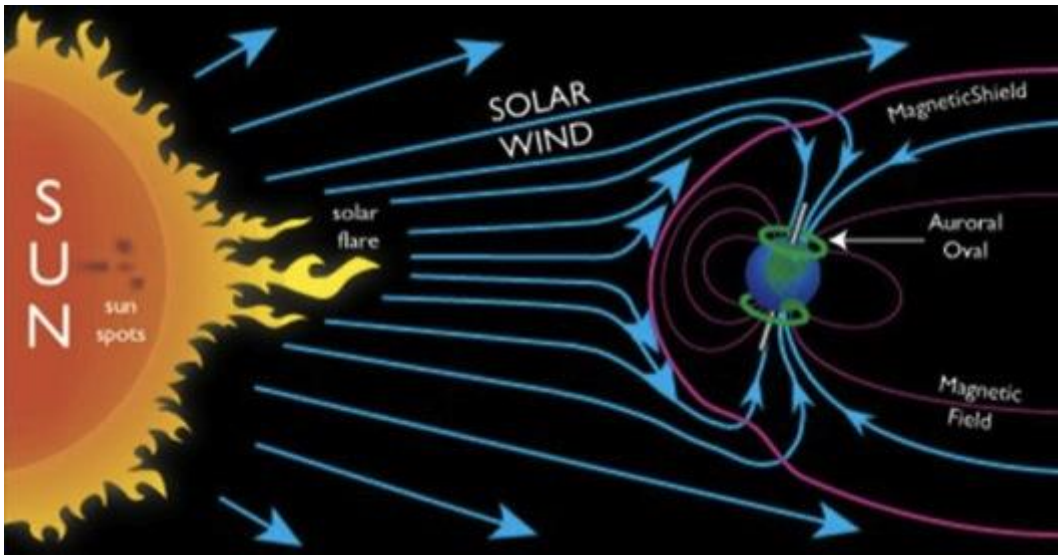

Figure 1. The magnetic field of the Earth as a Shield from lethal effects of solar wind [1].

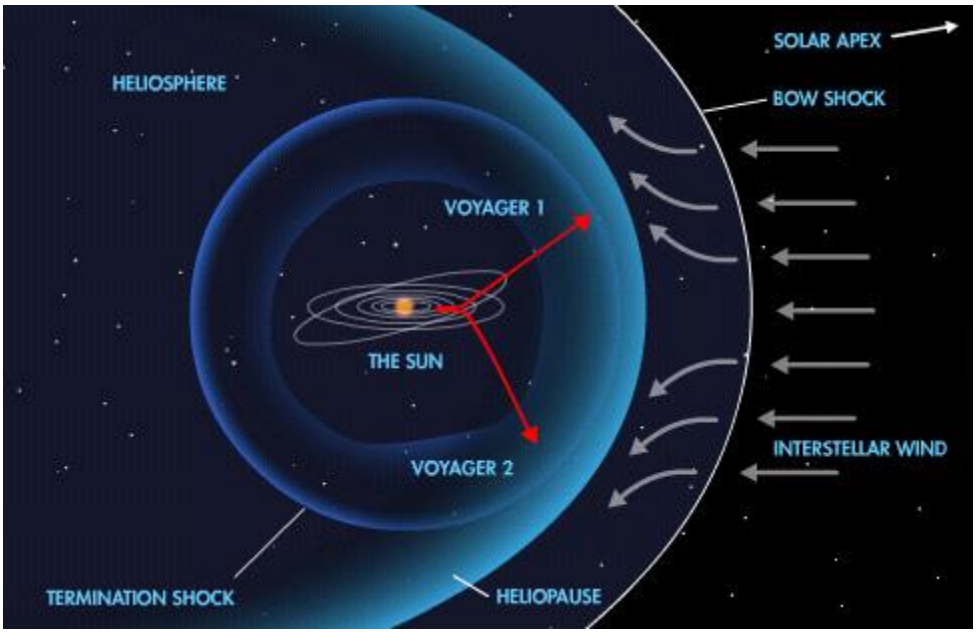

Figure 2. Colliding interstellar plasma with space probes [1].

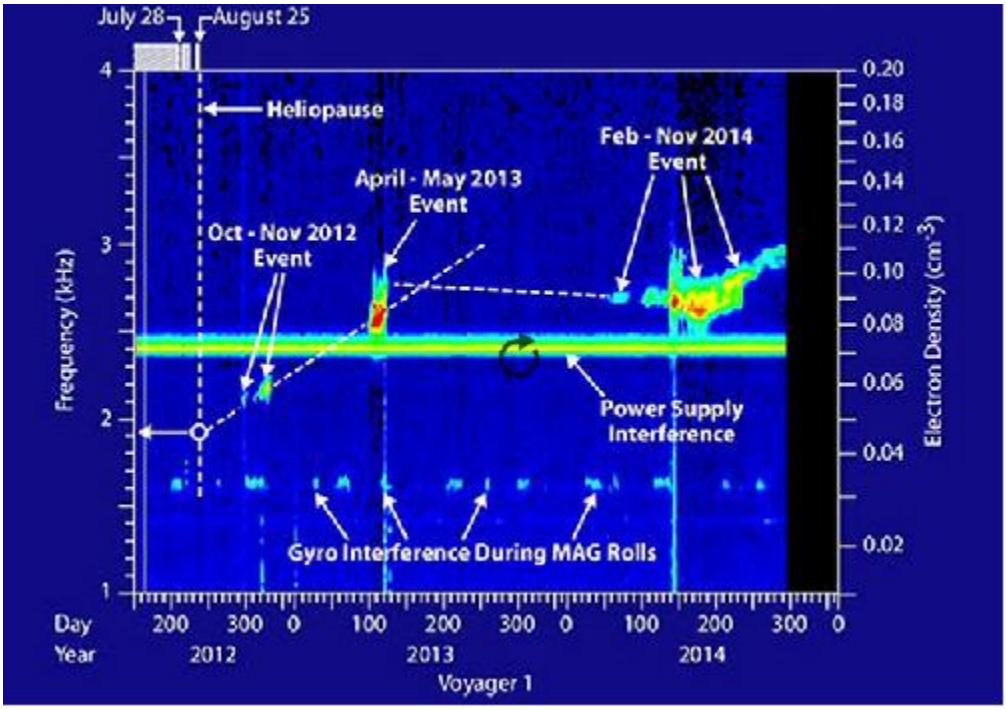

Figure 3.The graphic above shows the frequency of the waves, an indication of the density of the plasma. Colors correspond to the intensity of the wave, with red being the loudest and blue the weakest. Credit: NASA/JPL [4].

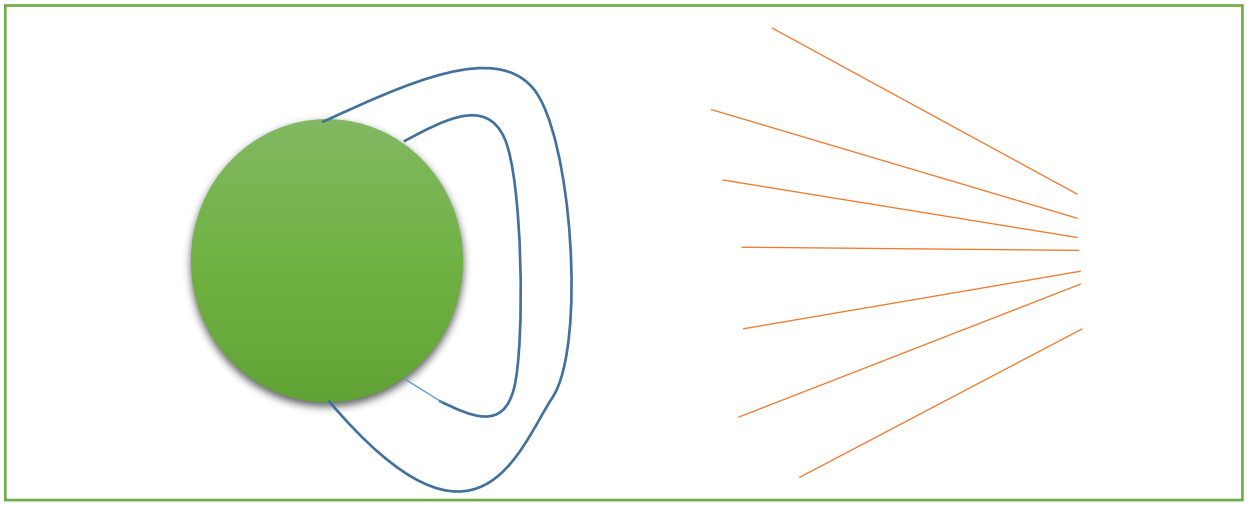

Figure 4. Proposed using artificial magnetic fields for protection of the space probes from solar or interstellar plasma. Red: incoming plasma particles, green: circular space vehicle, blue: artificial magnetic field made by solenoid or magnetic surface.

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