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THEORETICAL LIMITS ON JOVIAN RADIO BELTS

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The Jovian magnetosphere is a challenge to space plasma physics. As a consequence, the Jovian environment will be one of the aims of future particle-and-field missions. These missions are in great danger of being wiped out by the possibly strong Jovian radiation belts. Because only the relativistic electron population is known from observations and nothing is known about the proton population, theoretical studies are the only way to gain the information necessary for the spacecraft engineer.

The construction of a reliable, self-consistent, proton belt model would be very difficult at the present time. A more practical but more restricted approach is to derive upper limits by considering the stability of possible radiation belts. We shall consider the instability of the Jovian counterpart of geomagnetic pulsations, known as pcl's, "pearls," or hydromagnetic whistlers. The instability is driven by radiation belt protons in the disk-like region around the equatorial plane of Jupiter. This region is shown in Figure 1. The region between the field lines near Io and Europa is the region in which our theoretical model plays a significant role. We see that a wavelet of small amplitude entering the instability region is amplified by the instability. If the amplification is too strong the waves will react back on the particles, diminishing the proton number by throwing them into the ionosphere. There is therefore a flux of amplifying protons that cannot be exceeded. This is essentially the upper limit on the belts we are looking for. Figure 2 shows the results of my calculations. The energies noted on the curves denote the proton energy above which the interaction takes place at a certain planetary radial distance. The lower solid curve shows the fluxes at which the mechanism described begins to work. The upper curve gives the upper limit, which cannot be exceeded. For comparison the dashed lines show the flux of terrestrial protons above 0.56 pJ (3.5 MeV) at the position of its maximum value. We see that the proton fluxes at picojoule (megaelectron-volt) energies in the Jovian belts may be more than 100 times the terrestrial ones. By coincidence the upper curve corresponds roughly to the maximum fluxes that the magnetic field of Jupiter can trap. We cannot give limits that will reduce the concern of spacecraft engineers about possible radiation damage inside 10 radii. The virtue of the method used lies in the fact that it needs relatively few assumptions as to the nature of the Jovian magnetosphere.

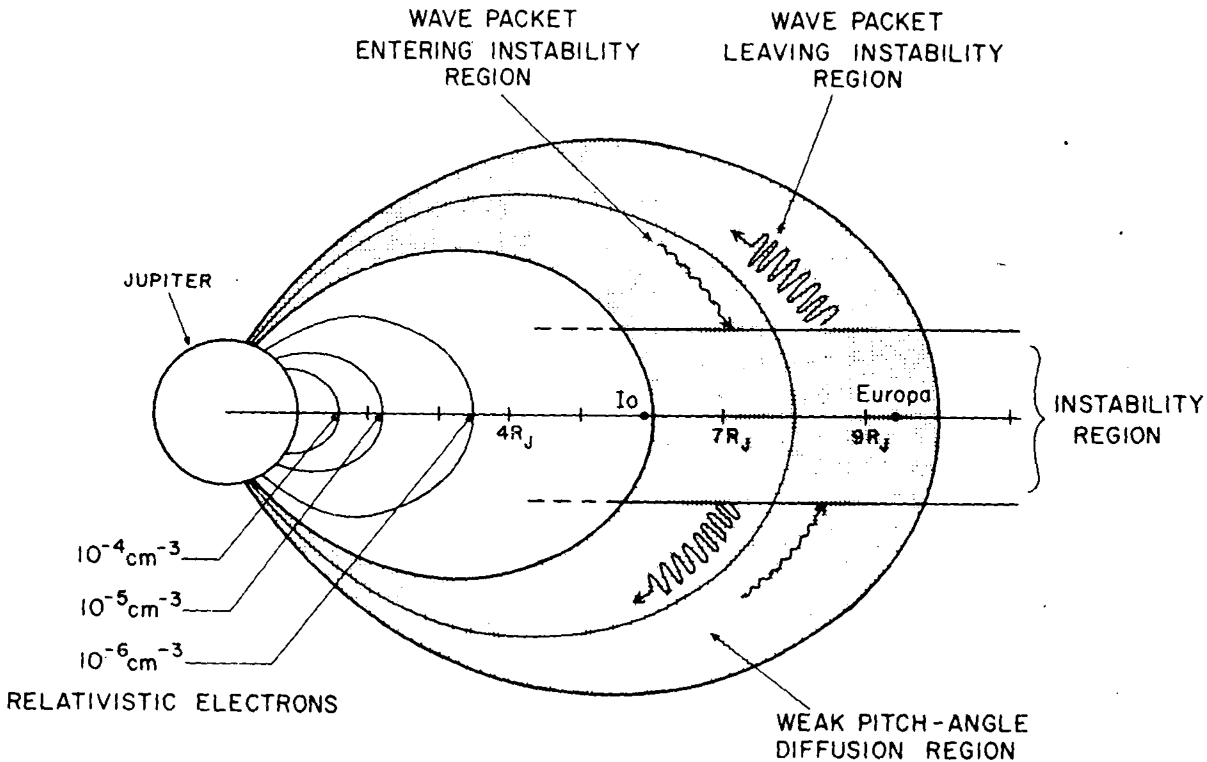

Figure 1–The environment of Jupiter showing the instability region in the radiation belts. (The positions of the relativistic electron belts are from Ref. 1.)

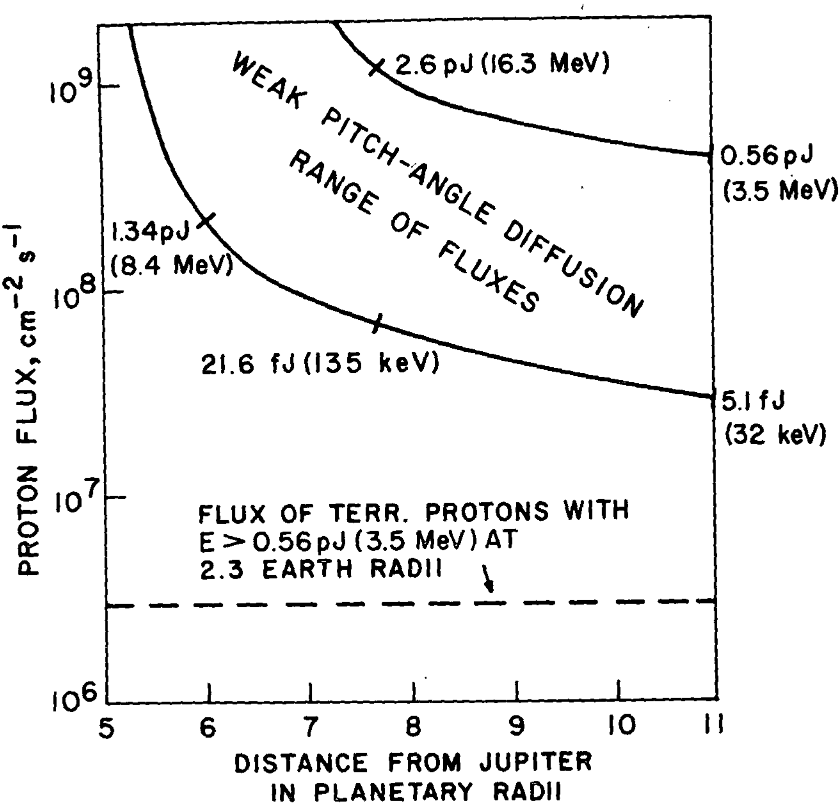

Figure 2–Calculated proton fluxes.

REFERENCE

1. Luthey, J. L.; and Beard, D. B.: Equatorial Electron Energy and Number Densities in the Jovian Magnetosphere. Proc. Jupiter Radiation Belt Workshop, Jet Propulsion Laboratory (Pasadena, Calif.), July 13-15, 1971, to be published.