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The ring arcs of Neptune

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After the corotation resonance with an exterior satellite proved inapplicable to the Neptune ring arc confinement, a search for other mechanisms settled on the possible influence of Neptune's magnetic field. The areas of greater optical depth around the ring are much dustier than the low optical depth regions. These particles reside in a plasma and must therefore carry some charge. Fig. 1 shows the components of Neptune's magnetic field on the equator at the radius of the ring arcs as a function of Neptunian longitude. The components are those of the offset tilted dipole model of Ness *et al.*, (1989). Although the dipole model is probably not a good approximation so close to the planet, the magnitude of the field given in Fig.4 is probably not too far wrong. The possible importance of the magnetic field on the smallest particles in the ring is indicated by the ratio of the magnetic force to the central gravitational attraction with the field strength $B = 0.01$ gauss at the ring distance.

$$\epsilon = \frac{qa(n - \Omega)Ba^2}{GMmc} = 2.2 \times 10^{-4}|V|,$$

where q is the charge, a the radial distance from the planet center, n the orbital angular velocity, Ω the rotational angular velocity of Neptune, G the gravitational constant, M and m the masses of Neptune and the particle respectively, c the velocity of light and V the particle electrostatic potential in volts due to the charge q, where V may exceed 10 Volts. The numerical value on the right hand side assumes m is that for a 0.5 micron particle of density $1\,\mathrm{g/cm^3}$.

A preferred position in the orbit for magnetically perturbed particles seems to require a commensurability between the rotation of the planet and the motion of the particle in the orbit. The period of rotation is assumed to be that of the radio bursts at 16.11 hours. However, without a model for the radio emission, one cannot be absolutely sure. Jupiter's decametric radiation depends on Io's orbital position as well as the rotation, so a synodic periodicity might be appropriate. But the latter radiation is highly directed, whereas Neptune's was seen all along the spacecraft trajectory on the 16.11 hour schedule, *i.e.*, with no shifts in phase relative to a fixed longitude on the planet. The ring orbital period is 10.536 hours which is not commensurate with the rotation period. If the 16.11 hours is interpreted as a synodic period between the rotation and a satellite motion, the closest rotation periods to 16 hours are 15.9 hours if the satellite is 1989N4 and 18.2 hours if the satellite is Triton. The former is near, but not at, a 3:2 resonance with the ring particle motion. The problem deserves some more thought before a possible herding of small particles by the magnetic field is abandoned.

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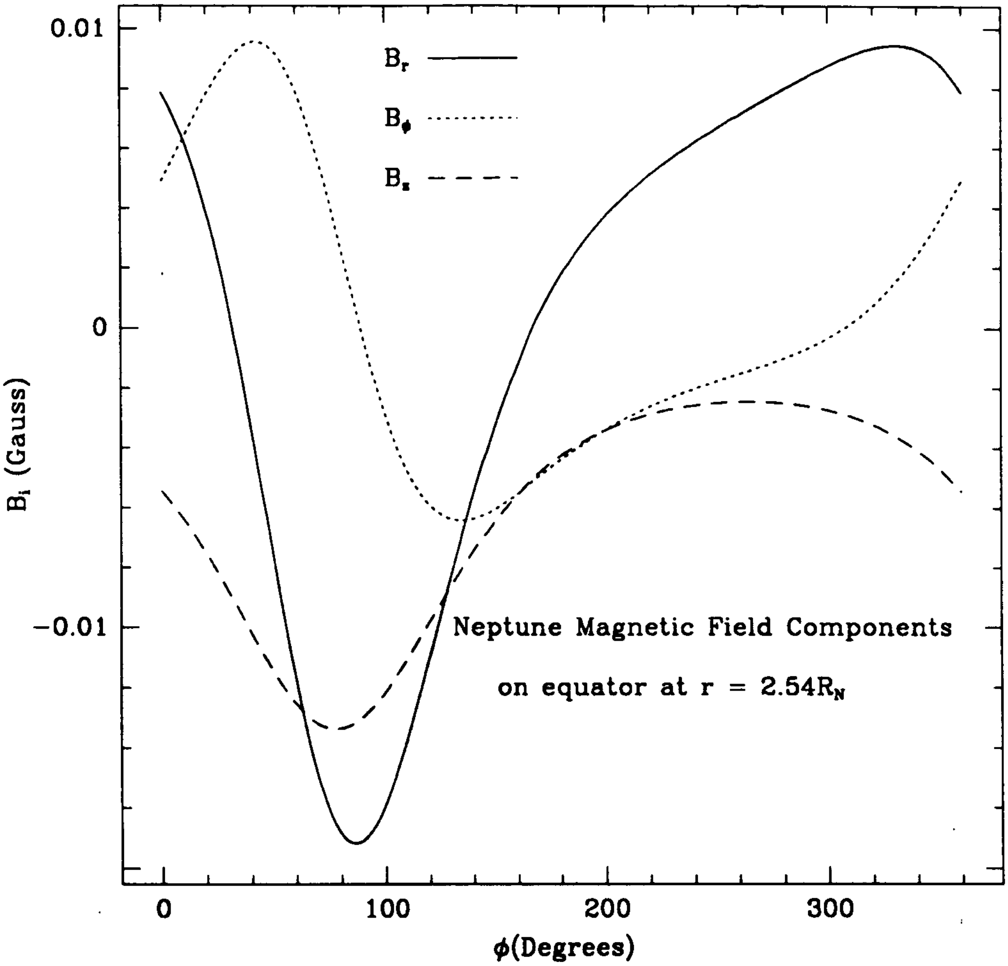
Reference: Ness, N. F., M. H. Acuña, L. F. Burlaga, J. E. P. Connerney, R. P. Lepping, and F. M. Neubauer (1989) Magnetic Fields at Neptune, bf Science 246, 1473–1478.

Fig. 1



0.01
0
−0.01
B_r
B_ϕ
B_z
Neptune Magnetic Field Components
on equator at r = 2.54R_N
B_i (Gauss)
0
100
200
300
ϕ(Degrees)