COSMIC RAY PARTICLE ACCELERATION IN PULSAR MAGNETOSPHERES

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A plausible approach to the theory of pulsars as cosmic ray particle accelerators is to integrate numerically the Lorentz-Dirac-equation, using the vacuum field of a rotating orthogonal magnetic dipole as a model field configuration. Typical parameter values are: angular velocity $\omega = 20\pi$/sec and magnetic dipole moment $\mu = 10^{30}$G cm^3 (K.O. Thielheim, Proc. ESO-CERN Conf. 1986).

Protons starting sufficiently near to the magnetic dipole are found to be focussed to one of the polar regions. Protons starting sufficiently far from the magnetic dipole finally evade to very large distances. Within a certain range of initial radial distance the ultimate fate of the proton depends on its initial angular position. This phenomenon can be exploited to define the "critical surface for protons", dividing the space around the magnetic dipole into two regimes: an interior one, from which protons are drawn towards the pulsar and an exterior one, from which protons are expelled to the interstellar space. Under given parameter values the latter is found at about 2 light radii distance from the dipole.

The ability of the field configuration to accelerate protons up to very high energies is found to break down beyond a certain range of radial distance from the magnetic dipole. Outside this "acceleration boundary for protons" the pulsar looses its ability to act as a cosmic ray proton accelerator. Under given parameter values the latter is at about 10.000 light radii distance from the dipole.

Our results therefore suggest that there is a certain region in space surrounding a pulsar from where charged particles can be accelerated to become primary cosmic ray particles. This region is limited for small values of radial distance by the "critical surface", and for larger values of radial distance by the "acceleration boundary".

According to the model suggested here, neutral atoms of the interstellar gas can invade the region between the "critical surface" and the "acceleration boundary" and be ionized there. They then become subject to the influence of the electromagnetic field accelerating them to become primary cosmic ray particles, the mass spectrum of which largely reflecting the chemical composition of the interstellar gas. Alternatively ions can be drawn from certain regions of the pulsar surface.

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