6.10 YOUNG PULSARS – PULSED NEUTRON SOURCES

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Abstract. The prospects of observing a pulsed neutron flux at very high energies from pulsars are discussed. Most likely candidates are the Vela pulsar at 2×10^{16} eV and the Crab Pulsar at 10^{17} eV.

It has been pointed out by several authors (Gold, 1969; Goldreich and Julian, 1969; Ostriker and Gunn, 1969) that pulsars are likely cosmic ray accelerators and that the total power as well as the maximum energies of the produced particles are large enough to explain the cosmic ray spectrum up to the highest energies which are of the order 10^{20} eV. Since the maximum particle energies will depend on the rotational period it is expected that at energies larger than 10^{16} eV the pulsar activity is limited to a rather short time after pulsar birth.

Shen and Pollack (1969) have shown that nuclei accelerated by pulsars will be effectively disintegrated at energies of 10^{15} to 10^{20} eV due to photonuclear reactions with the blue-shifted pulsed photon flux.

Now, during these photonuclear processes, a large number of high energy photoneutrons might be produced and we want to discuss in the following the prospects of observing them.

The decay mean free path of a neutron having a Lorentz factor γ is $\lambda = \gamma c \tau$ where τ is the rest lifetime of the neutron (1000 sec). Neutrons will reach us without appreciable decay losses from the Crab pulsar at 10^{17} eV, from the Vela pulsar at 2×10^{16} eV and from the galactic center at 10^{18} eV.

The neutron flux would be pulsed at emission and it is an interesting matter of fact that the neutrons would preserve their pulse structure during space travel. The delay at earth of a neutron with respect to a photon starting simultaneously is given by $\Delta t = d/2c\gamma^2$ where d is the distance of the pulsar. Δt turns out to be less than a few tens of microseconds for the sources and energies given above.

Moreover, it can be easily seen that deflection of neutrons by the interaction of their magnetic moment with the galactic magnetic field inhomogenities can be completely neglected.

Hence, young pulsars might show up as pulsed neutron point sources at very high energies where they might be detected by air shower techniques. The expected neutron flux from distant pulsars would not be large enough to reveal the pulse structure by shower observations alone. However, as has been shown above the neutrons should arrive in coincidence or with a constant phase with respect to the photon pulses.

In view of their ages and distances it seems to be doubtful whether neutrons could be detected from the known pulsars. The most likely candidates are the Crab pulsar at 10^{17} eV and the Vela pulsar at 2×10^{16} eV.

Davies and Smith (eds.), The Crab Nebula, 384–385.

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