Nature of "magnetars"

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A brief review of known models of Anomalous X-ray Pulsars (AXPs) and Soft Gamma-Repeaters (SGRs) is given. A new model is proposed to explain the main properties of these objects basing on the concept of drift waves in the vicinity of the light cylinder of a neutron star with the surface magnetic field $\sim 10^{12}$ G.

In the framework of this model we calculate rotation periods P, their derivatives dP/dt, and magnetic fields B in the regions of generation of radiation observed from AXPs and SGRs. The ranges of these parameters are $P = 11 - 737$ ms, $dP/dt = 3.7 \times 10^{-16} - 5.5 \times 10^{-12}$, $\log B = 2.63 - 6.25$. Radiation from AXPs and SGRs can be modulated with periods P. A strong relationship between the pulsed X-ray luminosity L_x of AXPs and SGRs and the rate of their rotation energy losses dE/dt is established. It coincides with the dependence of L_x on dE/dt for those radio pulsars whose X-ray emission has been detected. The slopes of the relationships $\log(dP/dt) - \log P$ and $\log \eta - \log P$ for AXPs and SGRs and for radio pulsars with short periods ($P < 0.1$ s) are equal (η being the efficiency of the transformation of the spin energy into radiation). Magnetic fields at neutron star surfaces calculated in the framework of the dipole model for AXPs and SGRs have the same order of magnitude ($\langle \log B_s \rangle = 11.90$) as for normal radio pulsars.

The observed quiescent X-ray emission of AXPs and SGRs can be explained by cyclotron radiation of electrons near the surface of a neutron star with the magnetic field $\sim 10^{12}$ G. The pulsed emission can be generated by the synchrotron mechanism near the light cylinder. Cataclysms on a neutron star can cause short gamma-ray bursts whose power exceeds the X-ray power by a factor of $2\ \gamma^2$ times, γ being the Lorentz-factor of emitting electrons. It is shown that in the 'magnetar' model the electron cyclotron line with the energy ~ 1 MeV must be formed. Its detection would be a good evidence in favor for this model.

It is shown that the drift waves near the light cylinder can also cause the modulation of the emission with periods of the order of several seconds in radio pulsars. These periods explain the intervals between successive pulses observed in radio pulsars with long periods ($P > 5$ s). Our model enables us to calculate real rotation periods of host neutron stars. They are shorter than 1 s for the investigated objects. The magnetic fields at the surfaces of neutron stars are $\sim 10^{11} - 10^{13}$ G, the same as for normal radio pulsars.

Pulsars of such types must have short periods ($P \lesssim 0.1$ s) and the small angle β between the spin and magnetic axes ($\beta < 10°$). It is expected that these pulsars constitute a rare (~ 0.01) fraction from the entire pulsar population. This estimate is in a good agreement with the known number of AXPs, SGRs and radio pulsars with very long periods.