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Non–Stationary Accretion in Her X–1–like Systems

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Accretion heats the neutron star crust thereby decreasing the electric conductivity in the solid region. This leads to a rapid field decay when the currents supporting the field are concentrated in the solid crust (Geppert & Urpin 1994, Urpin & Geppert 1995). Depending on the duration of the accretion phase and on the total mass accreted the field can be decreased by $3-4$ orders of magnitude after $10^6 - 10^7$ years. This mechanism explains the low magnetic fields of many pulsars entering binary systems.

However, there exist both low–mass (e.g. Her X–1, 4U 1626–67) and high–mass (e.g. Cen X–3, SMC X–1) systems, where the neutron star deserves strong accretion **and** the magnetic field is still large. These observations can be understood as follows:

Common features of these systems are:

- the neutron stars are old ($\geq 10^8$yr),
- the Roche–lobe overflow is in an initial stage (Savonije 1978, Taam & van den Heuvel 1986).

Hence, we consider accretion–driven magnetic field decay when

- neither the accretion rate
- nor the thermal structure of the crust have reached a steady state yet.

The accretion flow reaches its steady state faster than the thermal structure of the crust, the assumed temporal behaviour of both quantities is shown in the middle and lower panel of Fig.1. The age of the neutron star corresponds to the depth $z_0(\rho_0)$ penetrated by the field before accretion starts, the time scale of the field diffusion through the crust is $t_d \sim 10^7 Q^{-1}$yr. In the upper panel of Fig.1 the field evolution is represented. If the neutron star before the accretion phase possesses a crustal magnetic configuration confined to layers of not very high density ($\rho_0 < 3 \times 10^{13}$ g/cm^3), the field decay during the non-steady state phase may be rather strong. On the contrary, the magnetic evolution of neutron stars with deep crustal field configuration is very slow. The field can penetrate practically to the bottom of the crust for a neutron star of age $> 10^9$ yr if $Q > 0.01$. For such deep magnetic configurations, the field strength can be reduced only by a factor $2-3$ after 10^5 yr in comparison with its value before accretion starts. Our calculations, which are extendendly described in Urpin & Geppert (1996), show that the decay of the field may be very slow at the initial accretion phase and, in some cases, the field can even be reduced only by a factor $2-3$ after the first 10^5 yr. Thus, it is quite possible that the surface field strength of these bright X-ray sources is only slightly lower than that of isolated pulsars.

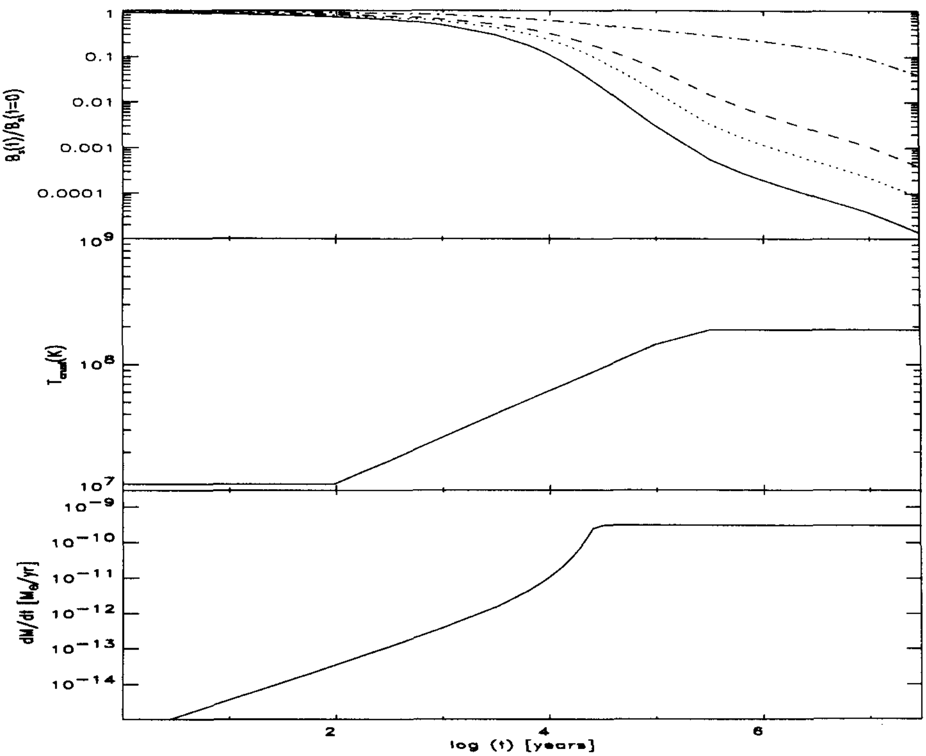

Figure 1. The time dependence of the surface magnetic field strength normalized to its value at the beginning of the accretion phase for different values of the initial depths penetrated by the field. The accretion rate is $\dot{M} = 3 \times 10^{-10} M_\odot$ and the impurity parameter $Q = 0.01$. The curves correspond to $\rho_0 = 10^{12}$ ($z_0 = 320$ m, solid line), 10^{13} ($z_0 = 411$ m, dotted line), 3×10^{13} ($z_0 = 483$ m, dashed line) and 2.8×10^{14} ($z_0 = 934$ m, dot-dashed line) g/cm^3.

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