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On the low magnetic fields of millisecond pulsars

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Millisecond pulsars (MSPs) are old and very fast rotating neutron stars (NS) with much weaker magnetic fields than the younger classical pulsars and magnetars. Most MSPs are in binary systems, suggesting a "recycling scenario", in which a classical pulsar accretes matter from its companion and as a consequence spins up. Although this scenario explains the fast rotation, it is not clear yet how the magnetic field is reduced. The standard scenarios attribute it to the accretion process, either by increasing the temperature and thus the resistivity of the crust, leading to dissipation of the currents (assumed to flow in the crust), or by diamagnetic screening of the field by the accreted matter (which is implausible, because of magnetic buoyancy and the stiffness of the magnetic field lines). We examine an alternative hypothesis, in which ambipolar diffusion expels the magnetic flux from the neutron star core, in this way driving its decay. This process is particularly effective during the long period in which the neutron star has cooled substantially and has not yet started accreting, making the final magnetic field dependent on the evolutionary time of the companion star (and thus its initial mass), and naturally yielding field strengths of the observed magnitudes. Our predictions also appear to be consistent with the observed distribution of magnetic fields of millisecond pulsars according to their companion type: He white dwarfs, CO white dwarfs, or neutron stars.

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