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Magnetic field decay in neutron stars

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We analyse physical grounds for large braking indices of some young radio pulsars and investigated four hypothesis explaining origin of large braking indices: (1) binarity, (2) magnetic field decay, (3) evolution of the obliquity angle, and (4) complicated multipole structure of the poloidal magnetic field. We find that the magnetic field decay is the only plausible explanation for the majority of large braking indices. The evolution of the obliquity angle can cause large n for certain initial obliquity angles only in the nonphysical case of vacuum magnetosphere. Plasma-filled magnetosphere gives n˜3 for all initial obliquity angles. Although large multipoles l=3,4 can explain unusual braking indices of some objects, these surface fields need to have strength well in excess of physical limits for a NS stability. Magnetic field decay can proceed with different speed in different NSs depending on the crust composition (crust impurity parameter Q) or cooling of NSs. It is derived from our simplified model that if a fraction of 10-20˜per˜cent of NSs are low-mass M˜1.1˜M⊙, the poloidal magnetic field decays fast due to large phonon resistivity causing the braking index to reach values n=10-100. The same effect can be obtained if a similar fraction of NSs have extreme crustal impurities Q˜20-200, however, then they are doomed to loose their magnetic field rapidly. Observations of NSs in HMXBs do not support such high fraction of low-field relatively young compact objects.

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