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Unification of strongly magnetized neutron stars with regard to X-ray emission from hot spots

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Strongly magnetized isolated neutron stars (NSs) are categorised into two families, according mainly to their magnetic field strength. The one with a higher magnetic field of 10^{14} - 10^{15} Gauss is called "magnetar", and the other is the X-ray isolated neutron star (XINS) with 10^{13} Gauss. Both magnetars and XINSs show thermal emission in X-rays, whose spectra are different. The spectrum of a magnetar is reproduced with a two-temperature blackbody (2BB), whereas that of an XINS show only a single-temperature blackbody (1BB) with the temperature being even lower. On the basis of the magnetic field and temperature, it is often speculated that XINSs may be old and cooled magnetars. However, no strong observational evidence has yet been reported to support the speculation. Here we report that all the seven known XINSs show high-temperature emission, which should have a similar origin to that of magnetars. Analysing all the XMM-Newton data of the XINSs with the highest statistics ever achieved, we find that their X-ray spectra are all reproduced with a 2BB model, similar to magnetars, as opposed to the traditional 1BB model. Their emission radii and temperature ratios are also similar to those of magnetars except for two XINSs, which show significantly smaller radii than the others. The remarkable similarity in the X-ray spectra between XINSs and magnetars suggests that their origins of the emission are also the same. The lower temperature in XINSs can be explained if XINSs are older than magnetars. Therefore, this results is the first observational indication that supports the standard hypothesis of classification of highly-magnetised NSs. With our results, new questions have also emerged. For example, the temperature is separated clearly between magnetars and XINSs, which may suggest potential existence of a "missing link" between them.

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