

PHAROS Conference 2020: The multi-messenger physics and astrophysics of neutron stars



Contribution ID: 46

Type: **Oral Presentation**

Thermal spots and light curves of magnetars: 3D MHD simulations

Monday 30 March 2020 15:15 (15 minutes)

Using 3D MHD code, we explore magnetic field configurations with different contributions of the toroidal component. We solve coupled magneto-thermal equations in the NS crust on Myr timescale for magnetic fields of $1e14$ G. In this research, we confirm previous findings that a large fraction of the toroidal magnetic field leads to the formation of small magnetic spots.

In general, we see a formation of a complicated pattern as an overlap of hot spots (belts and filaments) formed due to the Ohmic heating of the crust and one caused by crustal thermal transparency along the magnetic field lines. A presence of the toroidal magnetic field component strongly modifies the size of hot magnetic poles, making one of them smaller than another. The models with a small contribution of the initial toroidal magnetic field show weak variations in lightcurves at the maximum level of a few percents depending on the orientation of NS and its compactness. The model with 90 percent contribution of the toroidal magnetic field misaligned with the poloidal magnetic field forms a single hot spot which could cause up to 80 percent variation of soft thermal flux.

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Session Classification: Parallel 2B

Track Classification: Magnetic field formation, structure and evolution