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# Spin-down evolution of magnetars: a novel approach to estimate their ages

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Magnetars are slowly rotating, young, and isolated neutron stars with surface dipole magnetic fields exceeding the quantum electrodynamic magnetic field limit. They exhibit highly energetic behavior, as in the case of soft-gamma repeaters (SGRs) and anomalous X-ray pulsars (AXPs). Recently, they have been studied with paramount interest by almost every modern X-ray telescope. Despite the success, the traditional picture of magnetars has been challenged by the discovery of low-field magnetar, SGR 0418+5729. It remains mysterious over the decades to interpret the evolutionary stage (or age) of such a puzzling source within the magnetar paradigm. Unlike ordinary radio pulsars, the characteristic age is not a reliable indicator for the true age of a magnetar. Here we provide a novel approach to estimate the realistic age of a magnetar. The methodology simultaneously accounts for the surface dipole magnetic field measurement as well. The previous studies for such field measurement are either based on an orthogonal vacuum rotator model or based on a force-free plasma-filled magnetospheric model of pulsars. In general, a real pulsar should be an oblique rotator surrounded by a plasma-filled magnetosphere with particle acceleration gaps to generate pulsar high-energy emissions. In this framework, we solve the self-consistent time evolution for magnetars, including the current state-of-the-art magnetic field decay mechanisms. The rotational period of magnetars increases over time due to the extraction of angular momentum by gravitational-wave radiations, magnetic dipole radiations, and particle winds. These torques also change the obliquity angle between the magnetic and rotation axes. In the peculiar case of SGR 0418+5729, we find a dipolar magnetic field of $1.0 \times 10^{14}$ G and a realistic age of 18 kyr; both are consistent within the magnetar paradigm.

References

[1] Mondal T., 2021, ApJ Letters, 913, L12

**Author:** MONDAL, Tushar (Indian Institute of Science)

**Presenter:** MONDAL, Tushar (Indian Institute of Science)

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