Magnetic fields of the outer solar nebula recorded in CR chondrites

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Paleomagnetic measurements on meteorites can infer the strength of magnetic fields in the evolving solar nebula. A recent study of the LL ordinary chondrite Semarkona suggests that its chondrules formed in a ~50 μT magnetic field 2 million years (My) after calcium aluminum-rich inclusions (CAIs) [1]. Meanwhile, a subsequent study of angrites suggests that local fields had decayed to ≤0.6 μT, implying local dissipation of gas by ~3.8 My after CAIs [2].

Chondrules extracted from the CR chondrite group exhibit radiometric ages as late as ~3.7 My after CAIs [3], while the isotopic systematics of CR samples have been interpreted as supporting an origin beyond the orbit of Jupiter [4]. As such, the recovery of paleomagnetic signals from CR chondrules may expand our knowledge of solar nebula magnetism to later times and larger orbital radii.

We have conducted paleomagnetic experiments on seven individual chondrules from CR chondrites. Our analysis of eight subsamples extracted from five chondrules of the LAP 02342 meteorite suggests that they formed in a magnetic field of ≤15 μT. Meanwhile, measurements of two dusty olivine-bearing chondrules from the GRA 95229 meteorite, performed with the high-resolution quantum diamond microscope (QDM; [5]), yielded a preliminary paleofield intensity of at least 32 μT. Together, these results suggest that nebular gas persisted in the formation region of CR chondrules until ~4.0 My after CAIs and that CR chondrules may have formed in a variety of magnetic field environments.

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