An Anti-glitch in the Magnetar 1E 2259+586

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Magnetars

- Young, isolated neutron stars (a few thousand years old)
- High $B$-field pulsars ($\sim 10^{14}$ G)
- X-ray luminosity can exceed spin-down power
- Outbursts with $\sim 100$ ms X-ray bursts, $\sim$months long X-ray flux enhancements

See Thompson & Duncan 1995,6; Thompson et al. 2002; and Beloborodov 2009 for more on magnetars

Image: NASA/GSFC
Glitches

- Hundreds seen in radio pulsars (eg. Crab, Vela)
- All spin-up glitches
- $\frac{\Delta \nu}{\nu} \sim 10^{-10} - 10^{-6}$
- Re-coupling of crustal superfluid and outer crust
- Magnetars have comparable glitches: $\frac{\Delta \nu}{\nu} \sim 10^{-7} - 10^{-5}$
- Magnetar glitches can be accompanied by X-ray outbursts

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See Espinoza et al., 2011 for more glitch statistics
See Dib et al. 2008 for magnetar glitches
Swift Monitoring of 1E 2259+586

- Started observing with Swift in July 2011
- Continued from 16 years of monitoring with RXTE
- \( B = 5.9 \times 10^{13} \) G
- Two spin-up glitches in 2002, 2007

See Kaspi et al., 2003 and Dib & Kaspi, in prep for prior 2259 activity.
Swift Monitoring of 1E 2259+586

Sudden Spin Down

Fermi GBM Detection
First anti-glitch seen in a pulsar
Internal origin: differential rotation of the superfluid
External origin: strong wind or sudden twist on the field lines
In a twist model, expect gradual relaxing of $\dot{\nu}$: Not seen
In a wind model, expect correlation between glitch epochs and X-ray flux: Not seen