State-change in the "transition" binary millisecond pulsar J1023+0038

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We report a change in the state of PSR J1023+0038, a source which is believed to be transitioning from an X-ray binary to an eclipsing binary radio millisecond pulsar (Archibald et al. 2009, Science, 324, 1411). The system was known to contain an accretion disk in 2001 but has shown no signs of it, or of accretion, since then, rather exhibiting all the properties of an eclipsing binary millisecond radio pulsar (MSP). Since its discovery as an MSP in June 2007 our regular monitoring with the Lovell Telescope (LT) at Jodrell Bank and Westerbork Synthesis Radio Telescope (WSRT) have shown it to be a steady radio emitter, apart from periods of orbital phase when it is eclipsed.

However this changed on June 23rd 2013, when the LT failed to detect PSR J1023+0038 at 1.4 GHz. Observations with the WSRT at 350 MHz and 1380 MHz showed that it was present on June 15th 2013. Since then, we have not detected PSR J1023+0038 in any of our, at least weekly, radio pulsar observations, including a full-orbit scan with the Green Bank Telescope (GBT) at 2.3 GHz (August 11th 2013) and a high-frequency scan with the Arecibo telescope (AO) (August 28th 2013) at 5 GHz. The corresponding pulsed flux density upper limits for typical observations at the aforementioned frequencies, assuming a 10-sigma detection threshold, are 0.8, 0.06, 0.016 and 0.003 mJy for the WSRT, LT, GBT and AO observations respectively. This contrasts with representative fluxes, away from eclipse, of 16 mJy and 0.9 mJy at 350 and 1380 MHz respectively. Thus, PSR J1023+0038 disappeared as an observable radio pulsar sometime between 19-23 June 2013.

Despite the dramatic change in the observed pulsed radio flux, daily Swift/BAT observations show non-detections with typical upper limits of the order of 10^35 erg s^-1 on the 15-50 keV luminosity (for power-law model with spectral index between 1.5 and 2, N_H ~ 4.3 x 10^20 cm^-2, and an assumed source distance of 1.3 kpc) since June 1 2013. The Swift/BAT was unable to observe the source in the period August 23 2013 to September 9 2013 due to Solar constraints. This low level X-ray activity rules out a high accretion rate or a thermonuclear burst. Tam et al. (2010, ApJ, 724, 207) pointed out that PSR J1023+0038 was a gamma-ray source during 2008-2010, and it appears in the 2FGL catalog of sources (Nolan et al. 2012, ApJS, 199, 31). A binned spectral analysis shows that the 100 MeV-300 GeV flux has increased from its

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long-term average of 1.07(13) x 10^-8 counts cm^-2 s^-1 to 4.9(9) x 10^-8 and 7(2) x 10^-8 counts cm^-2 sec^-1 during the periods from June 21 2013 to August 17 2013 and August 17 2013 to September 15 2013, respectively. Thus J1023 has brightened by a factor of ~5 in the gamma-rays since the radio pulsations disappeared.

We encourage further multi-wavelength follow-up.

The Fermi LAT is a pair conversion telescope designed to cover the energy band from 20 MeV to greater than 300 GeV. It is the product of an international collaboration between NASA and DOE in the U.S. and many scientific institutions across France, Italy, Japan and Sweden.

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