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Luminosity dependent change of the emission diagram in the X-ray pulsar 4U 1626-67

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We have discovered strong indications of a correlation between the appearance of the Fe $K\alpha$ emission line in the spectrum of the X-ray pulsar 4U 1626-67 and its luminosity and shape of its pulse profile. Spectroscopic analysis of the latest, simultaneous Chandra/RXTE observation of 4U 1626-67, revealed the presence of a narrow Fe $K\alpha$ emission line. The observation was performed when the source was in a high luminosity ($> 10^{37}$ erg/s) state. This feature was not present in previous Chandra and XMM-Newton observations, performed when the source was in a low luminosity regime. Timing analysis of archival XMM-Newton and RXTE data also revealed a major change in the pulse profile of the source. Namely, the pulse profile during the Chandra/RXTE, high luminosity, observation has a characteristic double peaked shape that is radically different from the pulse profile during the XMM-Newton observation when the luminosity was lower and the Fe line was not present.

The iron line parameters are consistent with reflection of X-ray radiation off an accretion disk truncated close to the magnetospheric radius of a high field pulsar ($B \sim 10^{12}$ Gauss). Furthermore, using our X-ray diagnostics method (Koliopanos et al. 2013 [1]), we showed that the relative faintness of the emission line, is consistent with reflection off a C/O rich disk, as expected for this system. We argue that the appearance of the line and the change in the shape of the pulse profile are correlated and are the result of a major modification of the emission diagram of the accretion column, from a pencil beam to a fan beam pattern. This change was caused by an increase in the mass accretion rate, as was theoretically predicted by Basko & Sunyaev in 1976 [2]. To our knowledge, this is the first time this combination of events has been reported and it opens up the possibility of observing similar events in other X-ray pulsars.

References

[1] Koliopanos F., Gilfanov M., Bildsten L., 2013, MNRAS, 432, 1264

[2] Basko M. M., Sunyaev R. A., 1976, MNRAS, 175, 395

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