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Unraveling the eclipse mechanism for black widow pulsar J1544+4937 using broad band radio spectrum
Extended Abstract

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Most of the millisecond pulsars (MSPs) are found in binary systems. A fraction of the binary MSPs in compact binary orbits with orbital period; $P_b \leq 10$ hours, show frequency dependent eclipses of the pulsar radio emission when the companion star comes close to the line of sight (superior conjunction) [1]. In these compact binary systems relativistic pulsar wind evaporate material from the companion star. Either the material blown from the companion star by the pulsar wind or the material inside the pulsar wind itself can absorb the pulsar radio emission and cause frequency dependent eclipses. These compact binary systems are natural laboratories to study the pulsar and stellar wind interactions, properties and stellar environment of low-mass stars in compact binary orbits and the gravitational behaviours of these compact binary systems. Thus we need to understand the physical environment of these binary systems to understand the evolution of them. Probing the eclipse mechanism is one of the major observational method to understand the overall physical environment of these exotic systems.

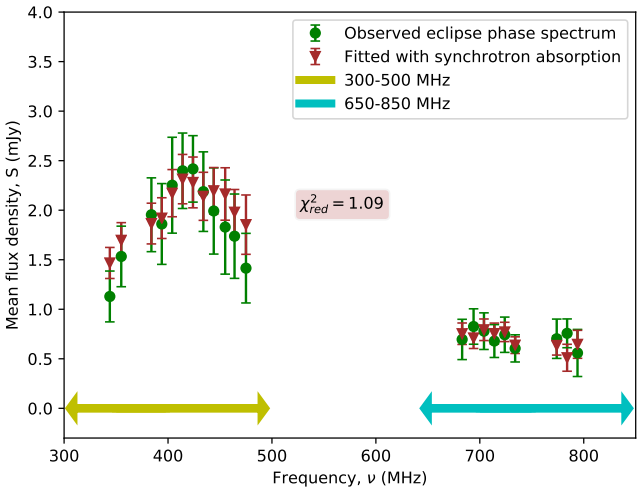

Figure 1. Fitting observed eclipse phase spectrum with synchrotron absorption by mildly relativistic electrons. Observed eclipse phase spectrum is shown by green circles. The best-fit spectrum with synchrotron absorption is shown by brown upper triangles. The modelled spectrum is well fitted with the observed eclipse phase spectrum and the reduced chi-square is 1.08.

Following the first discovery of eclipsing MSP B1957+20 [2], eclipse mechanism studies were performed for a handful of eclipsing binary pulsars (for e.g. PSR B1957+20 [2], PSR J2051-0827 [3], PSR J1544+4937 [4], PSR J1744-24A [5]). However, the physical mechanism of the frequency dependent eclipsing is still unresolved. The availability of the new wide bandwidth facilities allow to probe the eclipse medium while transitioning from optically thick to optically thin state which is ideal for understanding the eclipse mechanism. In this study we propose a new method for probing the frequency dependent eclipse mechanism utilising the broadband radio spectrum. We used the wide bandwidth observations with upgraded Giant Meterwave Radio Telescope (uGMRT) [6] between 300−850 MHz for this study. We demonstrated for the first time that broadband radio spectrum provide direct observational evidence of the eclipse mechanism. We successfully apply this for binary MSP J1544+4937. We have found that the synchrotron absorption by the mildly relativistic electrons in the eclipse medium can reproduce the observed spectrum at the eclipse phase (Figure 1). Thus the synchrotron absorption by the mildly relativistic electrons is causing the frequency dependent eclipse. This method also allows us to estimate some of the physical properties of the eclipse medium. Thus this method open a new window to provide observational constrain for more detail theoretical and simulation work on the plasma processes and pulsar and stellar wind interactions in these compact binary systems. This method when applied to other eclipsing MSPs will enable a valuable probe for studying the physical environment and evolution of these exotic binary systems.

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