Electron Cyclotron Maser Emission revealed in magnetic massive stars

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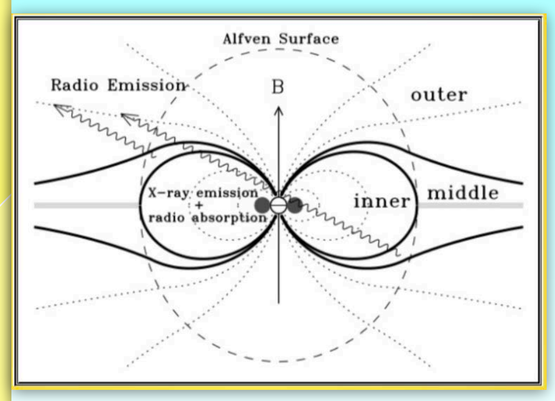
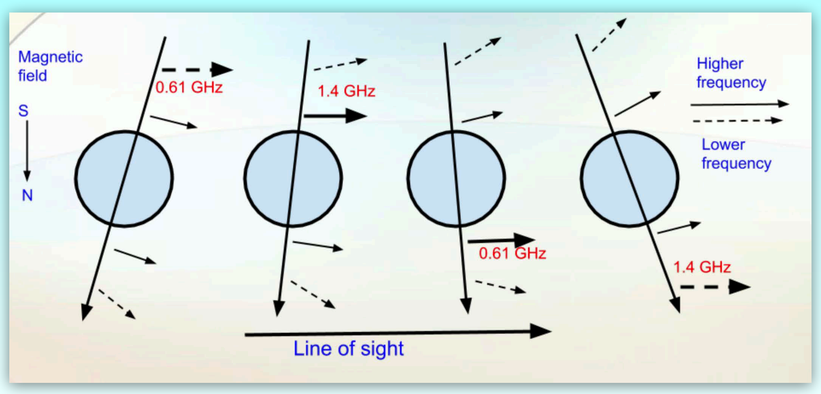
Abstract

As per current understanding, massive OB stars are the progenitors of most of the supernovae. However, magnetism in massive stars, which is rare and seen only in 10% of these stars, have important consequences in their rotational properties, mass-loss rates, thus their final fate as supernovae. While gyro-synchrotron emission, a consequence of magnetic fields in these stars, have been seen in a substantial fraction of magnetic OB stars, evidence of electron cyclotron maser emission (ECME) was seen only in one star, CU-Vir (Trigilio et al. 2000), until 2015, when we found evidence of ECME in another B-type star HD 133880 via our low frequency Giant Metrewave Radio Telescope (GMRT) observations. Since then we are carrying out a survey of magnetic massive stars and have found ECME phenomenon in 4 more stars. The ECME is a directional emission, seem to occur at the magnetic nulls of the stars. ECME appears to be a property at low frequencies, while the same stars show gyro-synchrotron emission at high radio frequencies. In this talk, we will discuss the detection of ECME, their implications in these stars' final demise as supernovae.

Electron Cyclotron Maser Emission in Magnetic AB stars

- 7-10% OBA are in our Galaxy are magnetic.
- In magnetic stars, gyro synchrotron radio emission arises from the middle magnetosphere, where stellar winds open the magnetic field lines forming a current sheet. Electrons are accelerated to high energies in these regions.
- These electrons eventually come back towards the star and emit by gyrosynchrotron and ECME under suitable conditions.

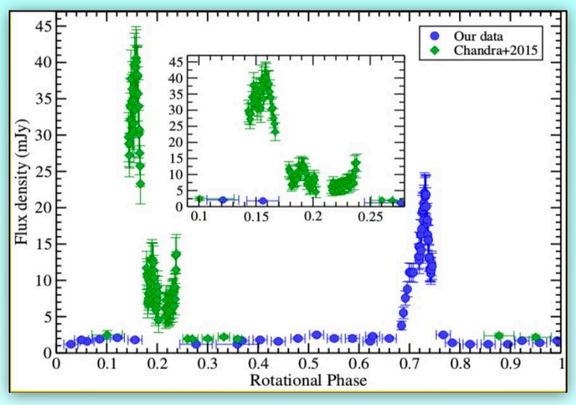




- ECME is more favourable at low frequencies, upgraded GMRT low bands ideal to probe it.

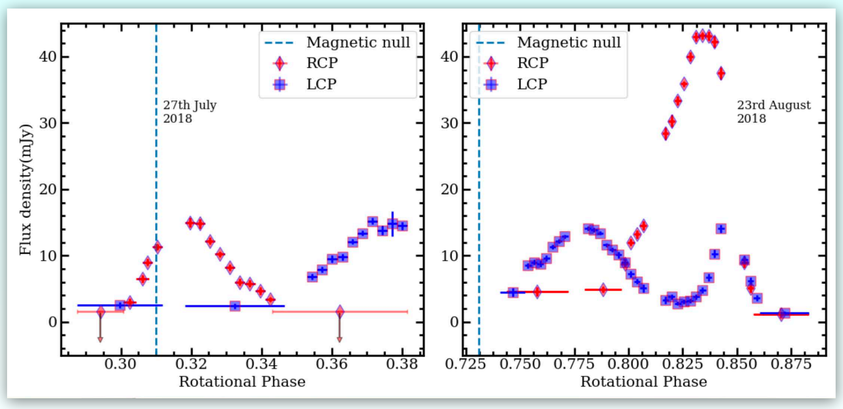
GMRT discoveries of ECME

- For more than 15 years CU-Vir was the only magnetic star with ECME phenomenon since 2000 (Trigilio et al. 2000).
- HD 133880 second star in which ECME is speculated with the GMRT observations (610 and 1390 MHz bands PC+2015).
- Study of full rotational period in HD 133880 - confirmed discovery of ECME at 1.4, 0.6 GHz bands. Gyrosynchrotron at ATCA bands.



HD 133880 at GMRT 610 MHz (PC+15, Das, PC+18)

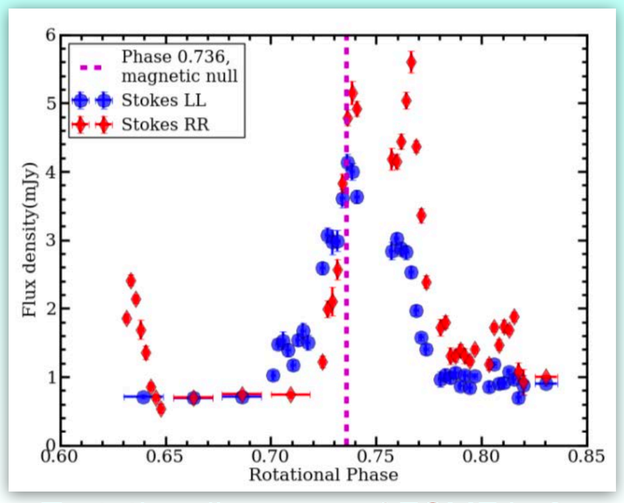
- Confirmed discovery of ECME in HD 142990 speculated by Lenc et al. (2018). Evidence for magneto ionic mode transition?

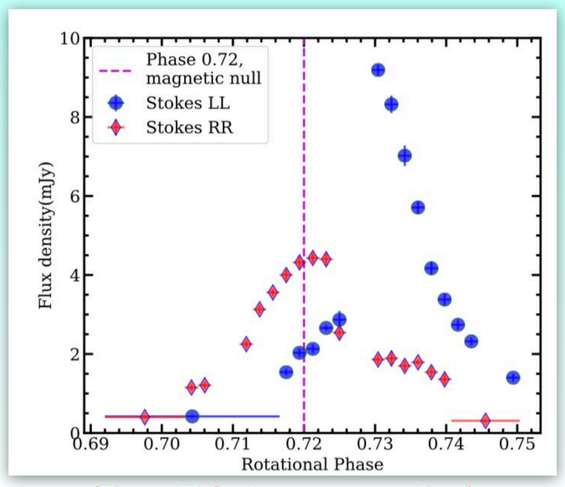


HD 142990 (Das, PC+19), signature of mode transition?

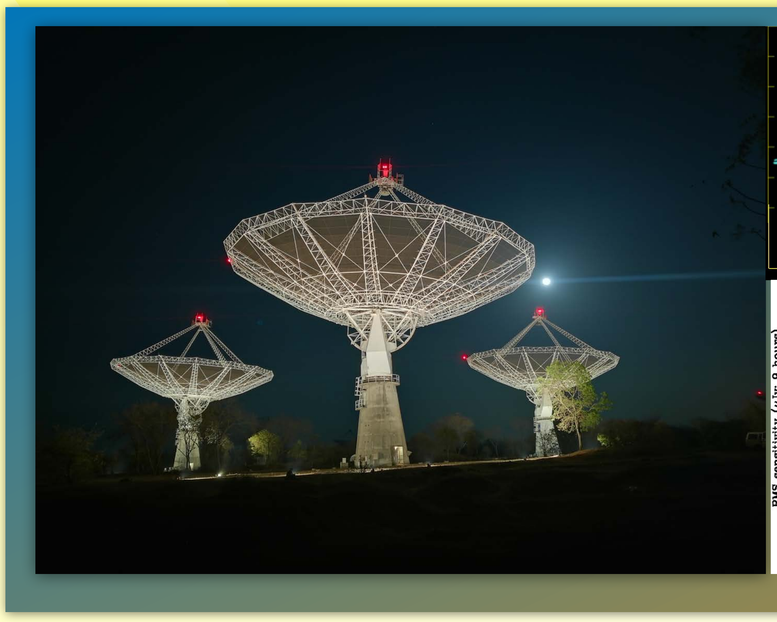
Two new discoveries

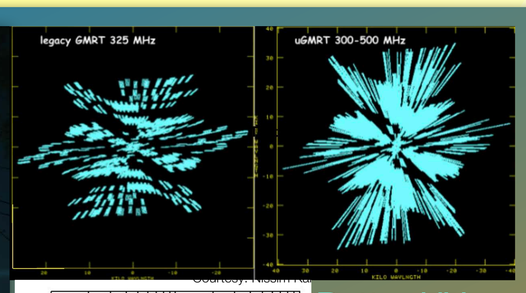
- Two more new detections ***(and many more to come!)***

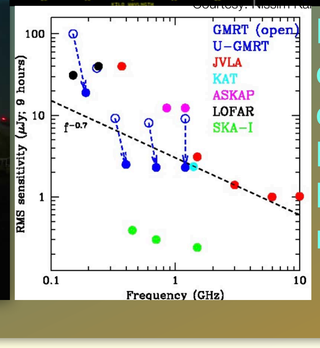




Tentative discovery of ECME in 2 new stars (Das, PC, in preparation)







Better UV coverage, continuous band, 3X higher resolution.

Conclusions and future directions

•ECME is favoured at low frequency. A survey is going on to discover and understand the phenomenon of ECME in the magnetic massive stars, which is likely to have huge implications on their demise as supernovae.

•References:

•1. Chandra, P., Wade, G., Sundqvist, J. 2015, MNRAS 452, 1245

•2. Das, B. Chandra, P., Wade, G. 2018 MNRAS 474, L61

•3. Das, B. Chandra, P. 2019, accepted for publication in ApJ, arXiv: 1904.08359