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Non-thermal emission in Cyg OB2

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Abstract. We report here on the first results from the Cyg OB2 Radio Survey (COBRaS), which is a UCL-led e-MERLIN legacy project to provide a deep-field radio mapping of the Cygnus OB2 association. The project has been awarded a total allocation of 252 hours at C-band (5 GHz) and 42 hours at L-band (1.6 GHz) to image the core of the cluster.

We discuss in particular the presence of non-thermal radio emission at 20 cm (L-band), and its potential as a highly efficient way to identify binaries via single-epoch observations, particularly for colliding-wind binaries. COBRaS data will provide a powerful tool for establishing binary incidence in Cyg OB2, specifically in the difficult intermediate-period range (1–100 yr).

Ultimately, we aim to assemble a substantial and uniquely sensitive radio dataset, which will be exploited to address several fundamentally important areas of stellar astrophysics, including mass-loss, binary frequency, stellar cluster dynamics, and triggered star-formation.

Keywords. radiation mechanisms: nonthermal, binaries: general, stars: early-type, associations: individual: Cyg OB2

1. The Cygnus OB2 Radio Survey (COBRaS)

The Cygnus OB2 association is located at the core of the Galactic Cygnus X region at a distance of 1.45 kpc (Hanson 2003) making it one of the closest young massive stellar clusters. It is known to contain a rich population of massive stars (Setia-Gunawan *et al.* 2003) including 120 $\pm$ 20 O-type stars and 2600 $\pm$ 400 OB-type stars (knödlseder 2000) and is tremendously rich in both its stellar density and diversity. As one of the most massive clusters in the Milky Way it offers direct comparison to not only massive clusters in general, but also young globular clusters and super star clusters found in high star-forming galaxies. Located behind the great Cygnus rift Cyg OB2 is heavily obscured making this ideal for radio studies.

COBRaS is an e-MERLIN legacy project (P. I. R. Prinja) awarded ~300 hrs of observing time to perform an intensive radio survey of the core of the Cygnus OB2 association in our Galaxy. We will conduct a uniquely probing, targeted deep-field mapping of this young massive cluster with two key science goals. A census of the massive stellar population via the thermal emission from the stellar wind will be used to calculate mass-loss rates and constrain the level of clumping within the wind. In addition, the detection of non-thermal emission will allow a study of the binary population within Cyg OB2.

The COBRaS observations will consist of mosaiced pointings covering approximately 20 square arcmins of the core of the Cyg OB2 cluster including 42 hrs at L-band (1.6 GHz) split over seven pointings with an rms noise of $\sim 15\,\mu$Jy and 252 hrs at C-band (5 GHz) split over 27 pointings with an rms noise of $\sim 3 - 4\,\mu$Jy.

The L-band observations were completed over three observing sessions: 24th Jan. 2014, 11th Apr. 2014 and 25th Apr. 2014. The analysis is ongoing and we present here some preliminary results from the COBRaS project.

2. Colliding winds in binaries

In a binary consisting of two early-type stars (e.g. O+O), the stellar winds collide and electrons are accelerated to relativistic velocities around the stationary shocks in the colliding-wind region (CWR). These CWR produce non-thermal synchrotron emission detectable at radio wavelengths as well as strong x-rays. Such emission has a steep spectral index ($\alpha \sim -0.7$) which can be distinguished from the thermal emission ($\alpha \sim 0.6$) expected from the stellar wind itself.

The e-MERLIN data from COBRaS will allow us to study in detail the individual binary systems and improve our understanding of the physics involved in particle acceleration within the shocks. These observations will also enable a statistical study of the colliding-wind phenomenon and better understand its dependence on stellar and binary parameters.

Accurate knowledge of the binary fraction is crucial for understanding the evolution of stellar populations and is a fundamental requirement for population synthesis models used to study the formation and evolution of stellar clusters. These COBRaS observations will provide single-epoch detection of binary systems enabling direct observation of the binary frequency within Cyg OB2 which is estimated to be ~55% (Kobulnicky *et al.* 2014). In particular, this survey will reveal the intermediate period binaries that are difficult to detect with optical studies.

3. COBRaS L-band detections - non-thermal emission

Approximately one fifth of the L-band observations have been processed and a number of non-thermal sources have been detected in the resulting images. Cyg OB2 #9 is just on example of the well-known binary systems. Cyg OB2 #9 is a highly eccentric O5-5.5I + O3-4III binary system with strong and highly variable radio emission (Blomme *et al.* 2014). Though only recently discovered as a binary, it is one of the most well-studied within the region and has been detected in the COBRaS observations with a flux density of 0.88 mJy.

A number of sources have been observed within the COBRaS data that have no formal identification and limited prior detections. SBHW90 is one example which was observed in a previous radio study at 1.4 GHz and 327 MHz with flux densities of 14.7 and 54 mJy respectively (Setia-Gunawan *et al.* 2003). This suggests SBHW90 may have a steep spectral index which could be from a CWR within a previously unknown binary system. These COBRaS observations provide the first resolved images of SBHW90 which has a flux density of 1.94 mJy at 1.6 GHz, suggesting this source may also be strongly variable.

The COBRaS observations will highlight a population of non-thermal emitting sources within the core of Cyg OB2 including known individual massive stars and binary systems. It is also expected to reveal a number of new sources such as young stellar objects, T-Tauri stars, new binary systems and protoplanetary disks as well as background radio galaxies.

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