COBRaS

Preliminary Results from the e-MERLIN Legacy Cyg OB2 Radio Survey

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Outline

- An introduction to COBRaS
- Key science goals
  - Mass-loss and clumping in the winds of massive stars
  - A study of the binary population
- Preliminary results from L-band COBRaS data
- The near future of COBRaS

COBRaS - Introduction

- COBRaS is an e-MERLIN legacy project awarded ~300 hrs of observing time.
- Intensive radio survey of the core of the Cygnus OB2 association in our Galaxy.
- Conduct a uniquely probing, targeted deep-field mapping of the young massive cluster.
- Offer direct comparison to not only massive clusters in general, but also young globular clusters and super star clusters.

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The Cygnus OB II Association

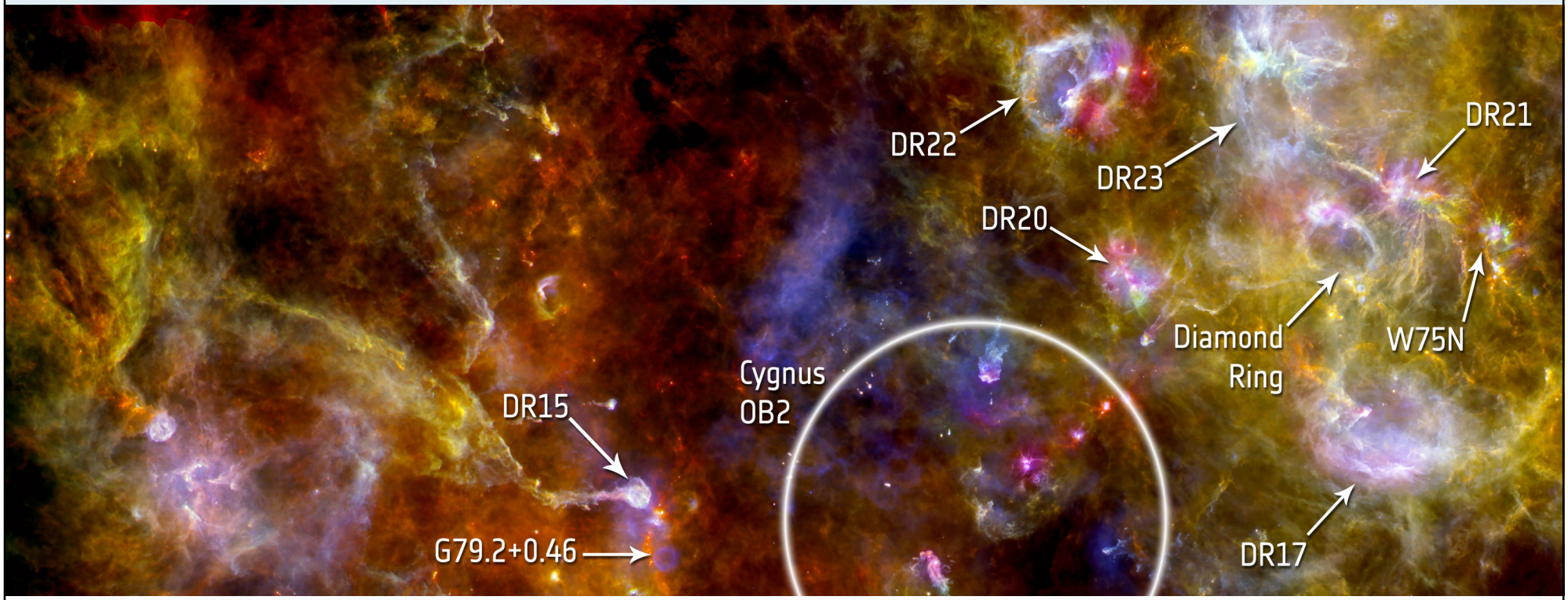


Image:ESA/Herschel/PACS/SPIRE/HOBYS Consortium

The Cygnus OB II Association

- Tremendously OB rich: 120 +/- 20 O-stars alone.
- Located a mere 1.7 kpc away in the core of the Cygnus X region.
- Large visual extinction – ideal for radio studies.
- Cluster mass: 4-10 x 10^4 M_o
- Estimated age: 2-3 Myr

Key Science Goals

- Accurate mass-loss determinations pulling constraints on wind clumping and stellar evolution.
- Studying the incidence of non-thermal emission in colliding wind binaries leading to a better binary fraction estimate.

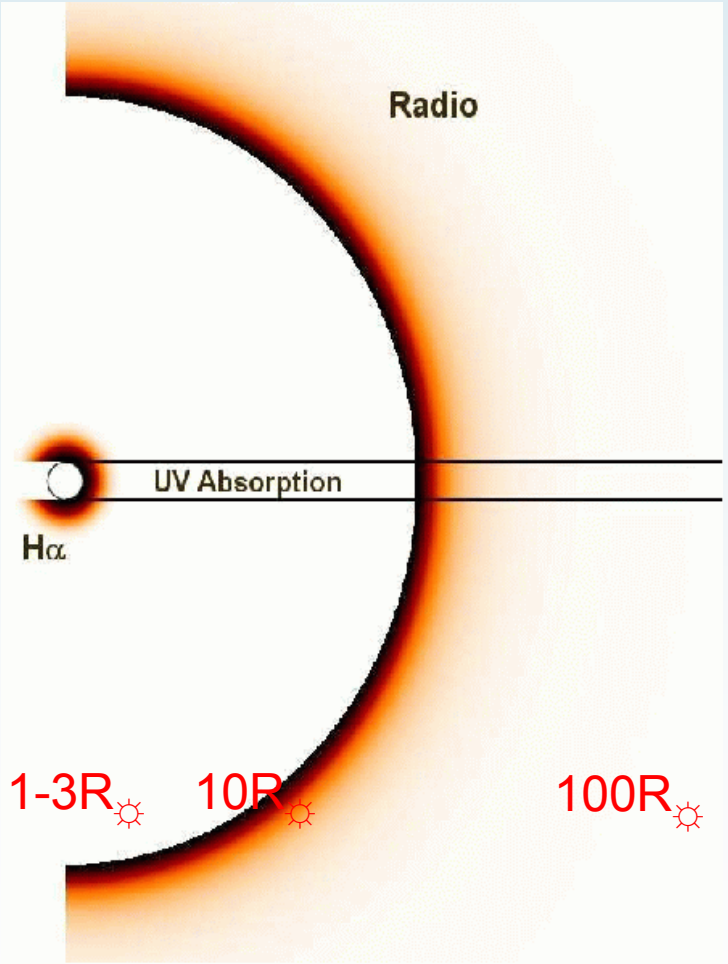
Mass-loss and clumping in the winds of massive stars: why bother...?

- Discordance of mass-loss rates via different diagnostics.
- Disagreement by an order of magnitude.
- Divergence from smooth wind to structured i.e. Clumping – causing over estimated mass-loss values.
- Implications:
  - Misguided view of OB star evolution
  - Impacts on feedback mechanisms back into ISM
  - Fundamental prediction to theory of radiatively driven winds

Mass-loss and clumping in the winds of massive stars: why radio?

- Three main diagnostics:
  - Free-free thermal emission in Radio arise at large stellar radii – ρ^2
  - Hα line NLTE modelling – ρ^2
  - UV P-Cygni resonance line profiles – ρ
- Not dependant on:
  - Velocity Field
  - Ionisation conditions
  - Photospheric profile

- COBRaS will take accurate flux measurements – determine mass-loss to constrain clumping.
- Combine with other datasets to study clumping as function of stellar radii



Binary populations in Cyg OB2

- Colliding wind regions from massive star binaries gives rise to non-thermal emission.
- Shock fronts in collision region produce synchrotron emission – steep spectral index.
- Differentiate from thermal radio emission using wide bandwidths.
- Study wind collision regions, individual binary systems and binary population.
- Single epoch confirmation of binary source
- No chance alignments

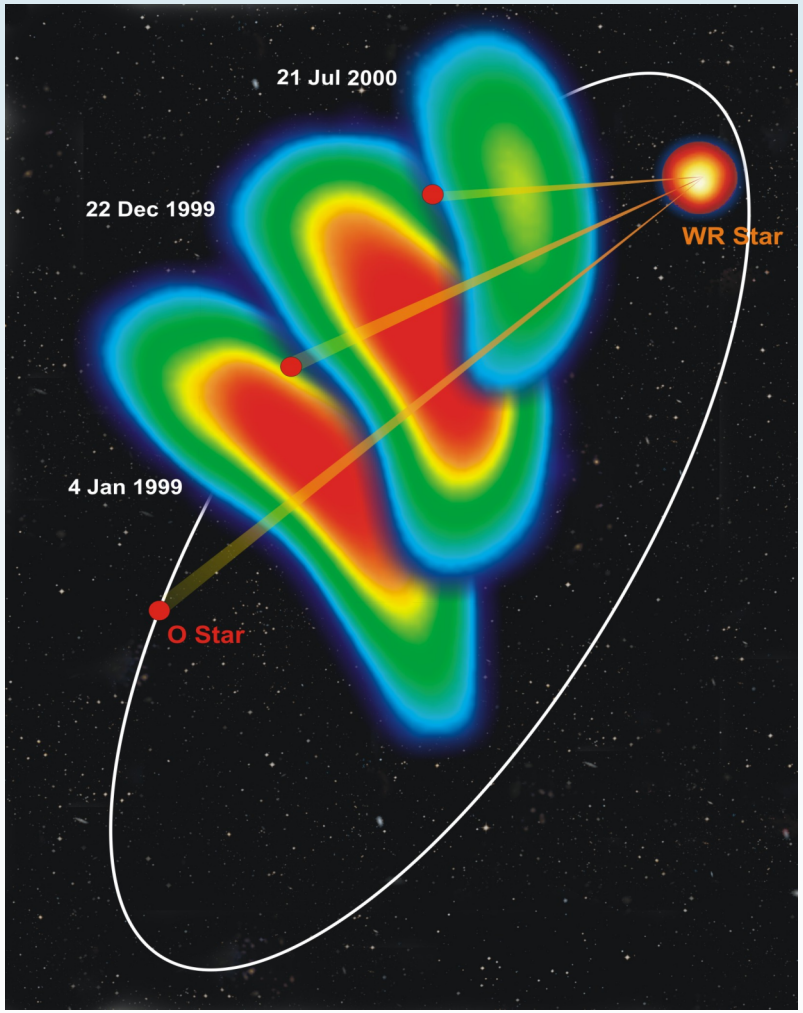


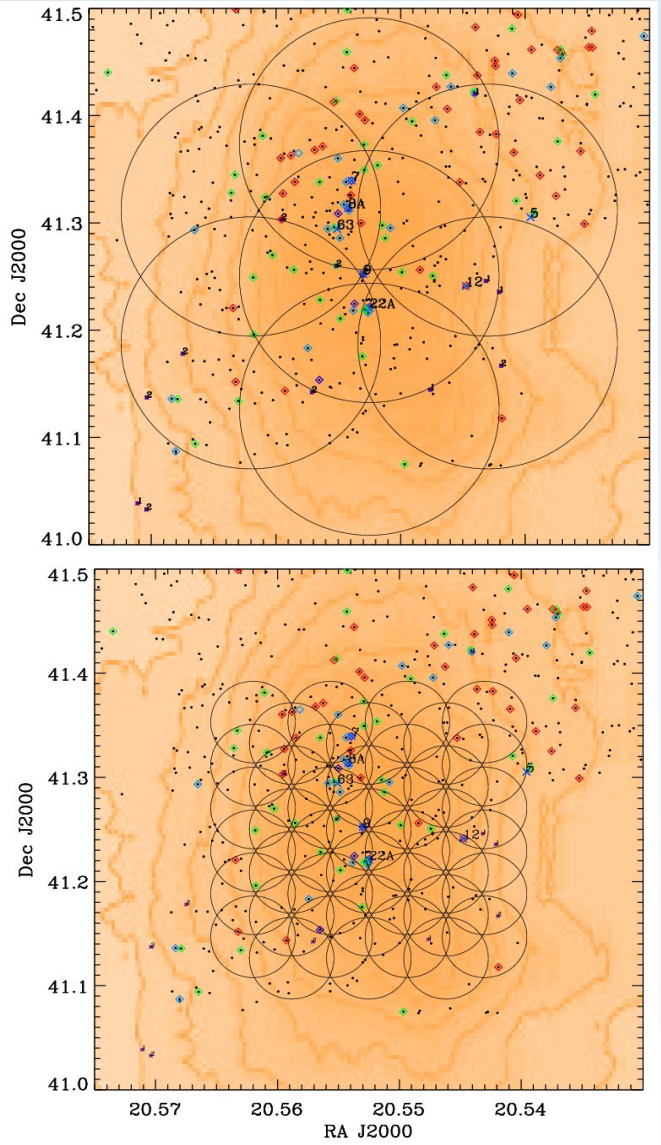
Image credit: Dougherty & Pittard, 2006, PoS (8th EVN) 049

Binary population

- Binary population of Cyg OB II estimated ~ 55% (Kobulnicky 2014) but uncertain...
- Direct observation of binary frequency
- Pivotal for understanding evolution of stellar populations
- Various population synthesis codes require knowledge of binary fraction/mass distribution/etc
- Binary properties important in constraining models of massive star formation.

COBRaS Legacy Observations

- Mosaiced observations of central region of cluster
- 42 hours L-band
  - 6hrs/pointing
  - Expected rms ~ 7-8 μJy
- 252 hrs C-band
  - 6hrs/pointing
  - Expected rms ~3-4 μJy

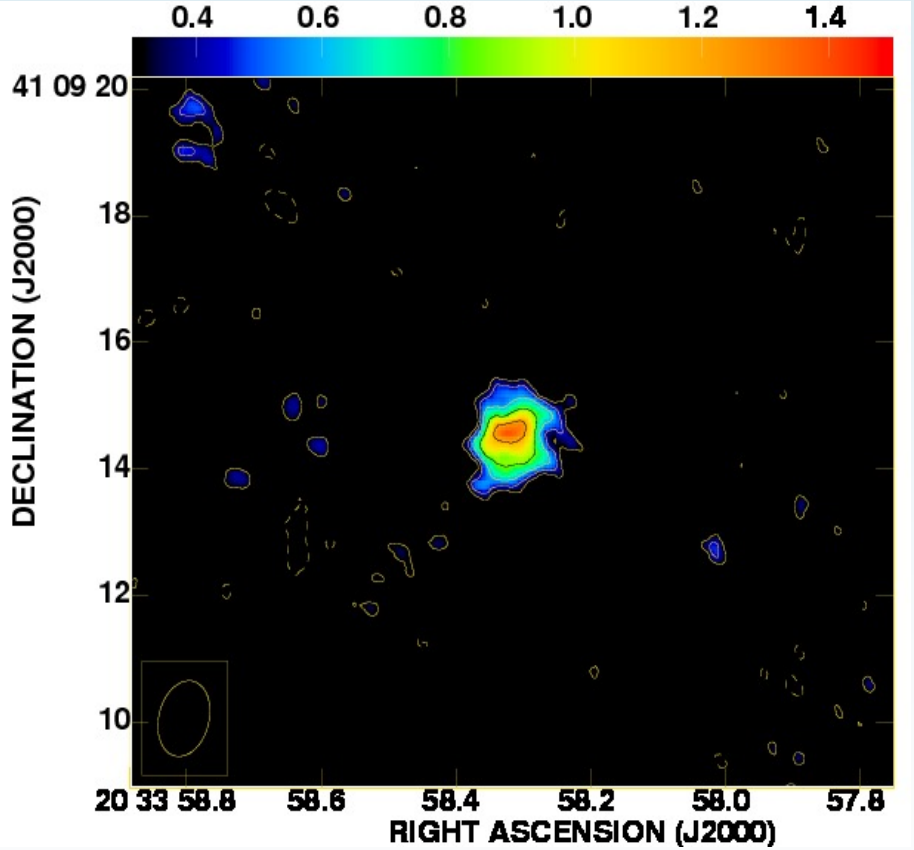


L-band Observations

- Two sets of L-band observations
  - Early 2013 data
  - Full COBRaS Legacy dataset in 2014
- Early 2013 data mostly calibrated
  - Imaged two central pointing, sources detected
- 2014 Legacy data received in it's entirety
  - Deep into calibration stage
  - On going...

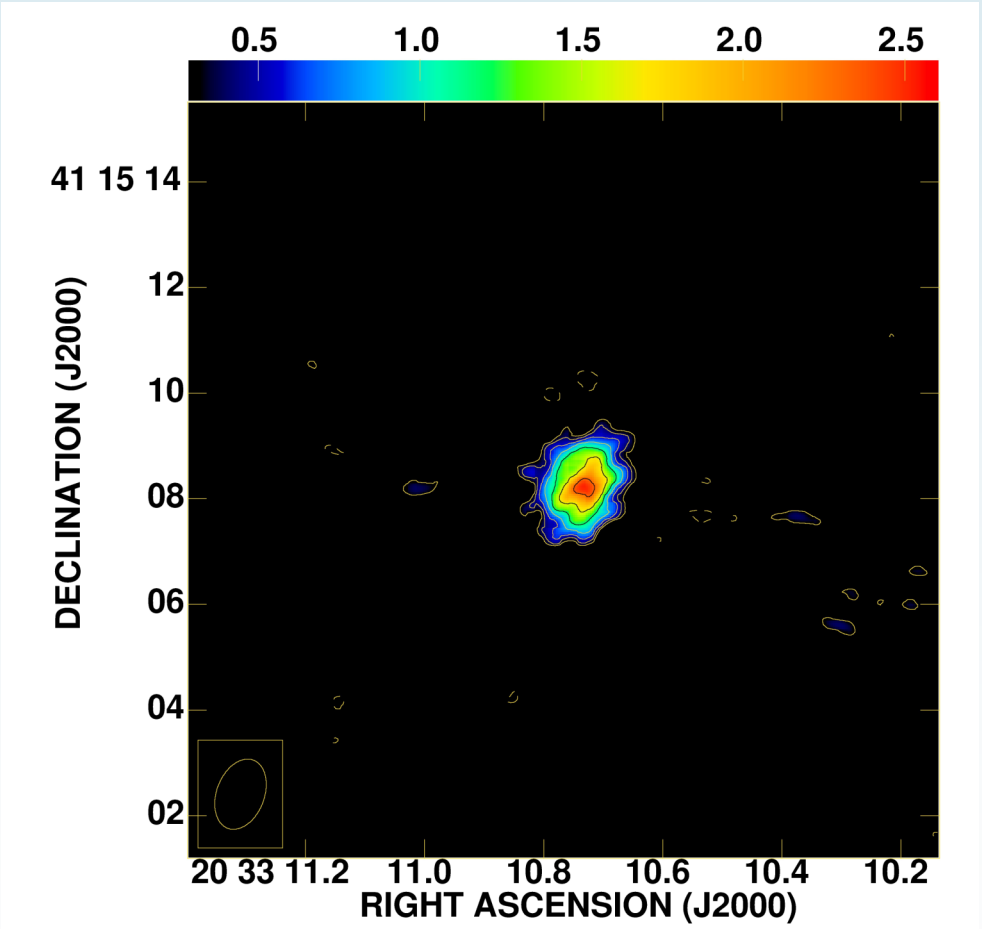
2013 L-band Observations: SBHW 112

- Identified source in pointing C (top right)
- Only ~56 mins on source
- IFs 3-8
- Matched to source from Setia et al, 2003
  - SBHW Continuum Survey of Cyg OB II
  - They imaged at 1400 with integrated flux 2.2 ± 0.3
- Our integrated flux ~ 1.5 mJy
  - RMS ~ 80 μJy/beam



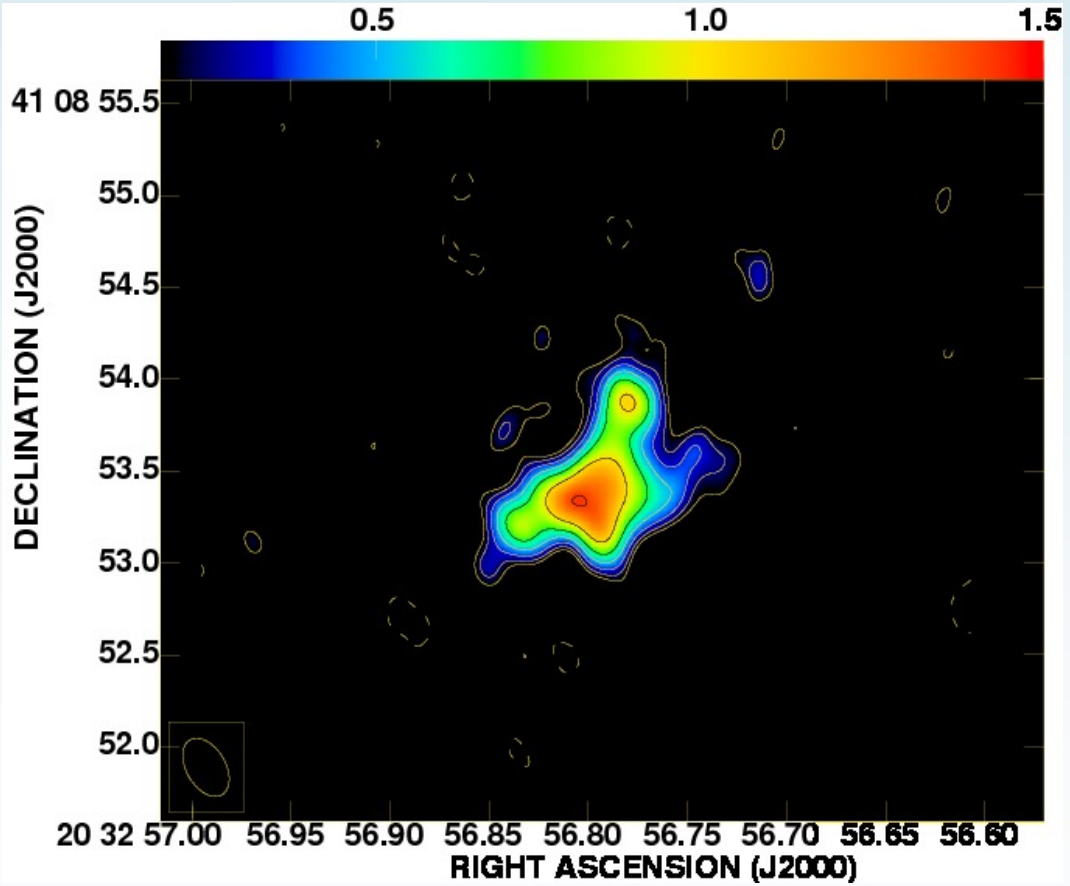
2013 L-band Observations: Cyg #9

- Pointing D ~ 54 mins on source
- IFs 3-8
- Well known and previously well studied binary system
  - see Nazé, et al, 2012 and Blomme et al, 2013:
    - O5-5.5I + O3-4III
    - Long Period ~ 860 days
    - High Eccentricity ~ 0.7
- RA: 20:33:10.74
- Dec: 41:15:8
- Integrated flux ~ 2.5 mJy



2013 L-band Observations: SBHW 90

- Two previous identifications both unresolved:
  a) Setia et al, 2003, SBHW 90:
     - 14.7 and 54 mJy at 1400 and 350 MHz
  b) Taylor et al, 1996, WSRTGP 2031+4058:
     - 15 at 327 MHz
- Our integrated flux ~ 6.3 mJy
  - RMS ~ 65 μJy/beam
  - First resolved radio image of source
  - Steep spectral index suggests binary system



What next for COBRaS?

- Legacy L-band dataset (42hrs) – currently processing
  - 6 sets of data
  - 1 set almost there, another already flagged
- Aim to completely calibrate entire L-band Legacy data by Christmas.
- That's only the beginning!
  - Imaging - source identification – flux measurements – mass loss estimates – clumping constraints – spectral index - binarity – mosaicing.
- C-band observations from 2015 (main dataset) calibrate/image as data pours in.

Consortia and further information

Website: http://www.ucl.ac.uk/star/research/stars_galaxies/cobras

- Ronny Blomme (Royal Observatory of Belgium)
- Simon Clark (Open University, UK
- Phil Diamond (JBCA, Manchester, UK)
- Jeremy Drake (Harvard-Smithsonian CfA, USA)
- Stewart Eyres (Univ. of Central Lancashire, UK)
- Simon Goodwin (University of Sheffield, UK)
- Ian Howarth (University College London, UK)
- Chip Kobulnicky (Univ. of Wyoming , USA)
- Julian Pittard (University of Leeds, UK)
- Salvo Scuderi (Astronom. Observatory, Catania)
- Ian Stevens (University of Birmingham, UK)
- Jacco Van Loon (University of Keele, UK)
- Martin Ward (University of Durham, UK)
- Dugan Witherick (Univ. College London, UK)
- Jeremy Yates (University College London, UK)
- Ishwara Chandra (GMRT, Tata Institute, India)

- Paul Crowther (University of Sheffield, UK)
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- Luke Peck (University College London, UK)
- Jack Morford (University College London, UK)