Tracing the chemistry in the clumpy shells around IRC+10216 with the VLA

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AGB stars and their circumstellar envelopes



The carbon star IRC+10216

- Often-studied carbon-rich AGB-star a.k.a. CW Leo
- Cool and luminous: ~2700 K, ~10 000 L $_{\odot}$
- Pulsation period: ~630 days
- Nearby: ~130 pc
- High mass-loss rate: $2x10^{-5} M_{\odot} yr^{-1}$
- Mass estimate: ~ 1 2 M $_{\odot}$
- C/O ~ 1.4
- more than 80 molecules detected

Winters et al. 1994, Men'shchikov et al. 2000, De Beck et al. 2012, Menten et al. 2012, Cernicharo et al. 2013



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Distribution of molecules and dust





~ 15 600 AU ~ 2 x 10¹⁵ m

- Karl G. Jansky Very Large Array, New Mexico, USA Interferometer: 27 antennas (25m) with new receivers, new correlator
- Spectral line and imaging survey of IRC+10216 in 2011 and 2013 (Mark Claussen, NRAO)
- Large coverage & bandwidth: 18 50 GHz, 2 GHz
- Unbiased unprecedented detail of ~1 arcsec resolution and ~1 mJy (per 125 kHz) sensitivity in ~ 51 hrs in total
- Tracing UV-induced photochemistry of outer CSE





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Keller et al., in prep.







HC₃N, HC₅N and HC₇N



Keller et al., in prep.

Morphology of CSE

- Mass loss process is variable
 - stellar pulsations?
 - cyclic magnetic activity?
 - binary system?
- Companion-induced spiral structure?
 - Orbital period: 55 yr, 800 yr
 (Decin et al. 2014, Cernicharo et al. 2014)
 - ➡ Position angle ~ 20 deg (Decin et al. 2014)
- Photochemistry of cyanopolyynes and hydrocarbons



Millar&Herbst 1994

Photochemistry around IRC+10216



Cordiner&Millar 2009

Radius (arcsec)

Morphological analysis

- Radial intensity profiles (assuming constant symmetric velocity field)
- Stellar position offset from center of emission
- Compare different quarters in detail





Radial profiles

Keller et al., in prep.



Radial profiles

	Keller et al., in p	orep.
average radius Q2 HC_3N : 17.9 ± 1 . HC_5N : 20.0 ± 1 . HC_7N : 21.9 ± 8 . C_3N : 21.3 ± 6 . average widths: 3-4	average radius Q1:" HC_3N : $14.0 \pm 2.0"$ " HC_5N : $15.4 \pm 1.9"$ " HC_7N : $16.5 \pm 7.7"$ " C_3N : $17.2 \pm 25.6"$ " average widths: $3-4"$	 Average radius increases: HC₃N ⇒ HC₅N ⇒ HC₇N ⇒ C₃N Q4 ⇒ Q1 ⇒ Q3 ⇒ Q2 Chemistry and dynamics
average radius Q32 HC ₃ N: $16.4 \pm 1.$ HC ₅ N: $18.3 \pm 0.$ HC ₇ N: $19.0 \pm 4.$ C ₃ N: 19.8 ± 11.2 average widths: 3-	average radius Q4: HC_3N : $12.9 \pm 1.3"$ HC_5N : $14.2 \pm 0.8"$ HC_7N : $15.4 \pm 5.0"$ C_3N : $16.0 \pm 14.1"$ u average widths: $3-4"$	 Refinement of fitting routine Further careful statistical analysis necessary

Summary









- New spectral line and imaging VLA survey of IRC+10216
- Detailed morphology analysis of carbon-bearing molecules
- Improve knowledge of morphology, mass loss history and chemistry of carbon-rich AGB stars

