ALMA observations of 99 GHz free-free and H40α line emission from star formation in the centre of NGC 253

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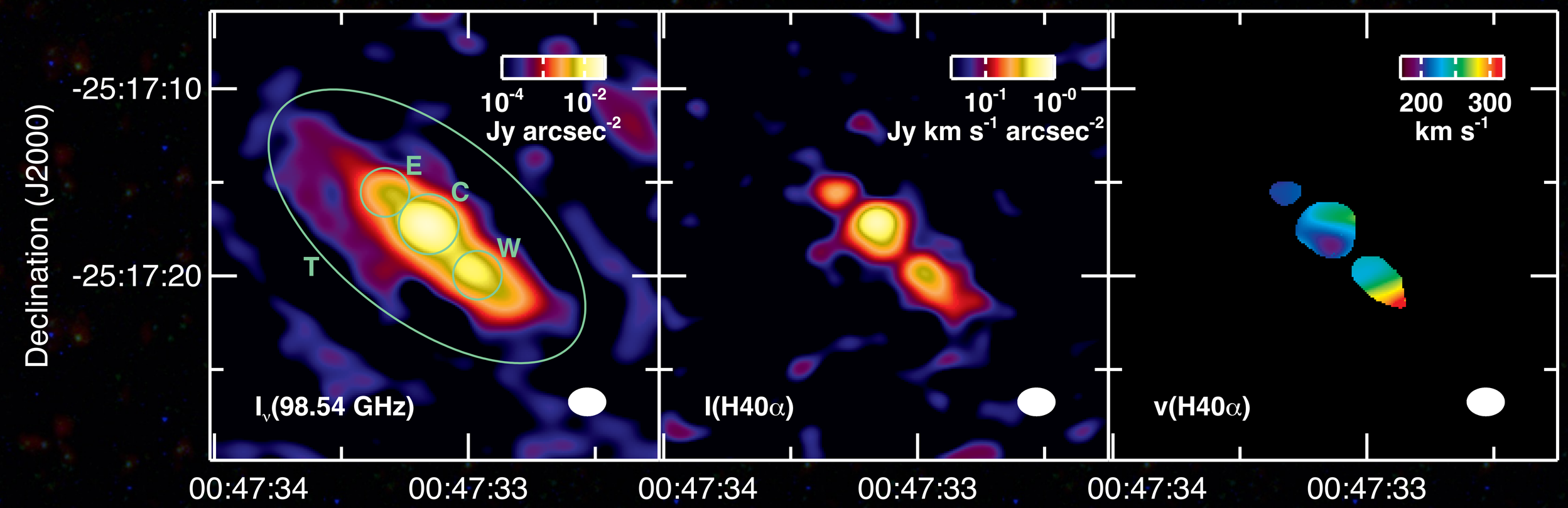
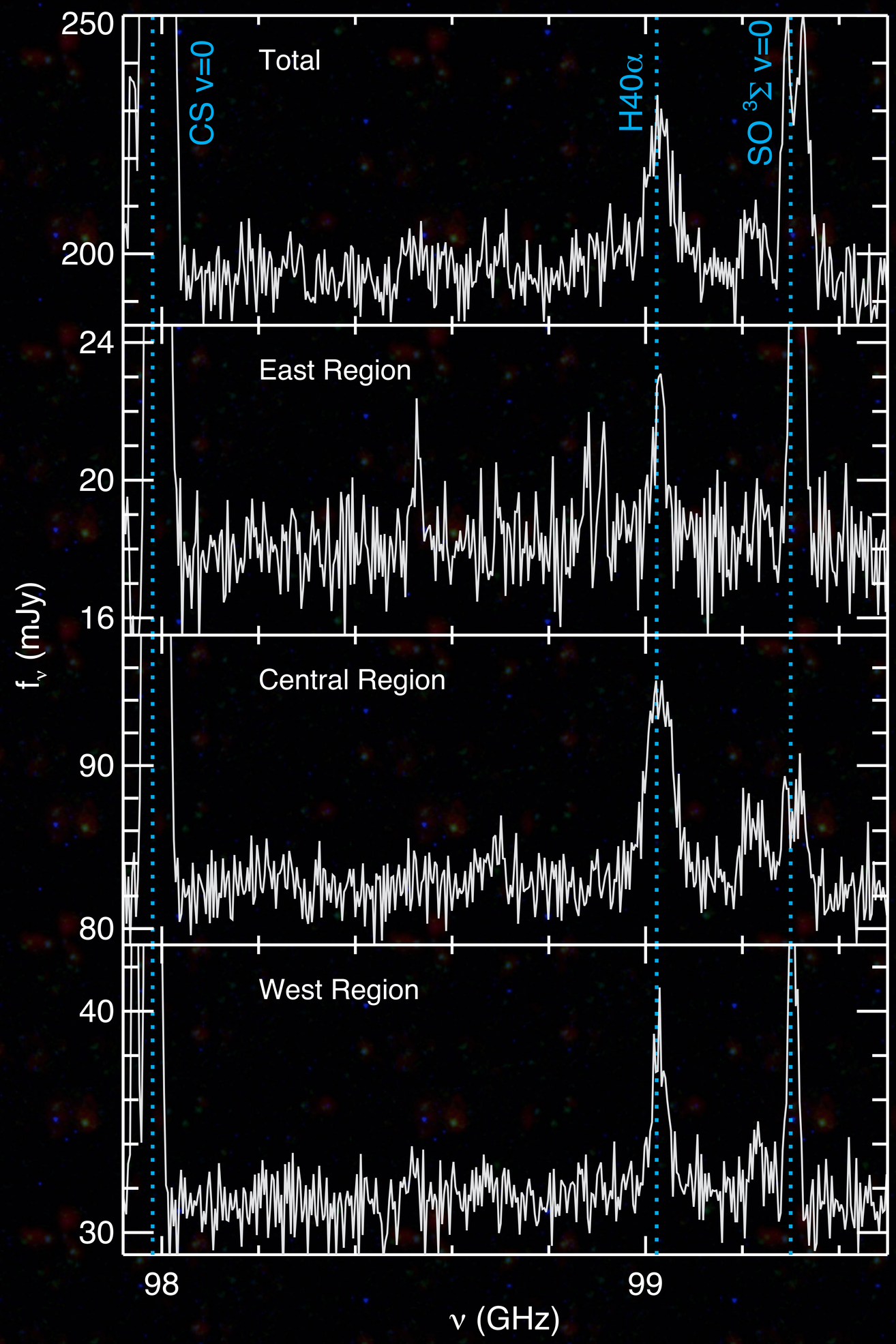


Images of the continuum surface brightness, the H40α intensity and the H40α mean velocity in the central 32″×32″ of NGC 253. The velocity is only shown for data where the H40 emission is detected at the 5σ level. The white oval in the bottom right of each panel shows the FWHM of the beam. The green regions in the continuum image show the total (T), east (E), central (C), and west (W) regions within which spectra were measured.



Spectra measured in the total, east, central, and west subregions shown in the image above. The frequencies are rest frequencies based on the velocities of the H40α line. The cyan lines show major spectral features identified using Splatalogue (http://www.cv.nrao.edu/php/splat).

Abstract

We present Atacama Large Millimeter/submillimeter Array obser-vations of 99.02 GHz free-free and H40α emission from the centre of the nearby starburst galaxy NGC 253. We calculate electron temperatures of 3700-4500 K for the photoionized gas, which agrees with previous measurements, and we measure a star formation rate of 1.73±0.12 $M_\odot$/yr within the central 20″×10″, which falls within the broad range of measurements from previous millimetre and radio observations but which are better constrained. We also demonstrate that the dust opacities are ~3 dex higher than inferred from previous near-infrared data, which illustrates the benefits of using millimetre star formation tracers in very dusty sources.

Electron Temperature (T_e)

- T_e can be estimated using the ratio of the H40α line emission to continuum emission.
- ALMA T_e measurements range from 3700 to 4500 K.
- ALMA T_e values are slightly lower than but consistent with previous measurements of T_e in NGC 253.
- ALMA T_e measurements are consistent with measurements of T_e in the centre of the Milky Way.

Star Formation Rate (SFR)

- SFR can be calculated using either free-free or H40α emission.
- Average of the two ALMA SFR measurements for the central 20″×10″ of 1.73±0.12 $M_\odot$/yr.
- ALMA SFR meaurements fall within broad range of previously-published SFR values based on radio data (0.5-5 $M_\odot$/yr), which suffer from a combination of problems:
  - Other lower frequency recombination line observations affected by masing, gas opacity, and sensitivity issues.
  - Other continuum-based SFR measurements sometimes rely on an old conversion from radio emission to SFR, while others are affected by spectral decomposition problems.
  - High resolution supernovae studies lack ability to precisely measure SFR.

Dust Attenuation

- Ratio of H40α emission to Paβ or Brγ emission(from Engelbracht et al., 1998, ApJ, 505, 639) yield $A_{pa\beta}$=5.0±0.2 and $A_{br\gamma}$=4.2±0.2 (assuming that attenuation is by a uniform sheet.
- Dust attenatuion measured using ALMA data is ~3 dex higher than measured using near-infrared data by itself.