MILLIMETER-WAVE MAPPING OF THE W3 CORE REGION AT 4 AND 6.5 mm

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Radio continuum observations of the core region of the compact H II region W3 at 6.5 and 4 mm wavelengths were made using the Nobeyama 45-m telescope. The 6.5-mm map agrees with lower-frequency maps, showing a major contribution of free-free H II emission. At 4 mm an excess over the H II emission is found, which indicates a contribution from dust grains. Comparing with sub-mm and FIR data, we suggest the existence of two dust components: normal dust at 50 K, and low-temperature (7 K), large-size grains (or interstellar "stones") in the region west of the W3 core.

The 46-GHz map (Figure 1) has a simple structure convolved from the three point-like sources W3A, B and C+D and a weak extended component north of C+D. The 75-GHz map (Figure 2) looks similar to the 46-GHz map. However, at 75-GHz a more extended component than at 46-GHz is found near W3-C+D. The 75-GHz excess relative to the 46-GHz emission is shown in Figure 3. The excess is distributed in the SW edge of the W3 core and is strong in the C+D region. The 46-GHz emission may mostly come from optically thin H II gas, while the 75-GHz emission comes from both the H II gas and dust grains.

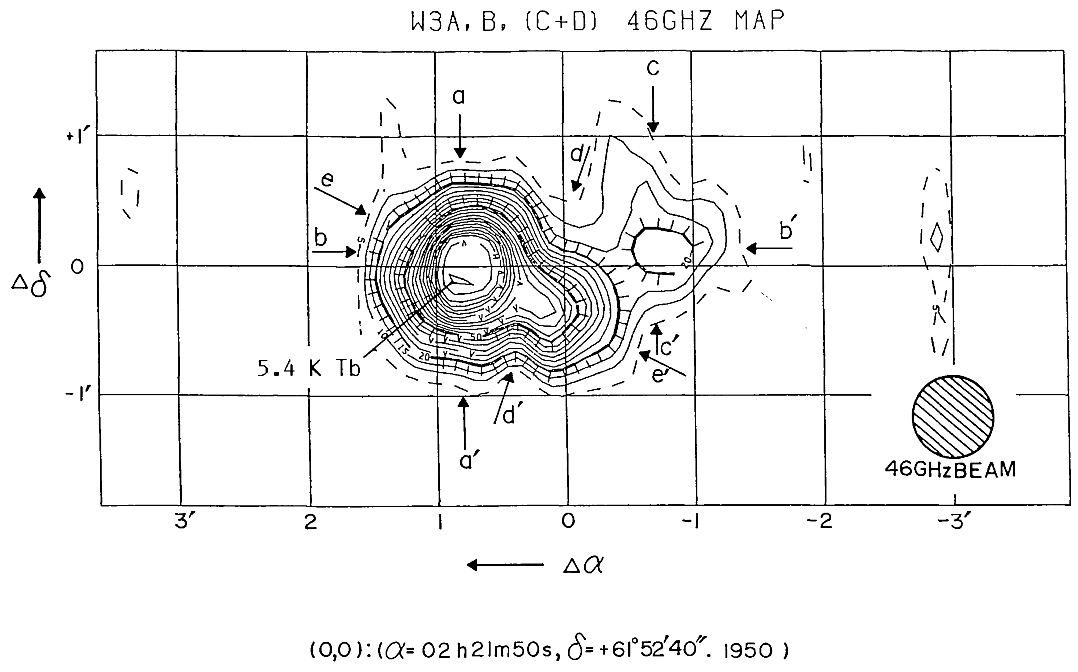

Fig. 1. A 46-GHz map of W3. The W3 peak contour of 120 corresponds to 5.4 K tb.

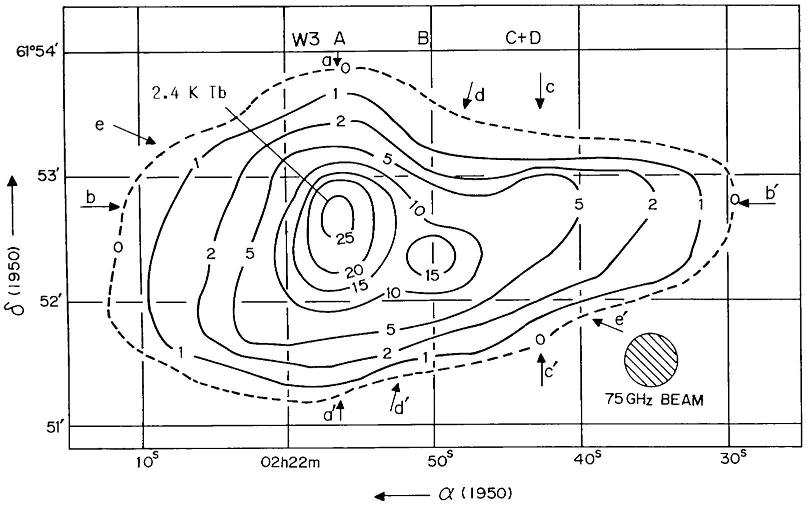

Fig. 2. A 75-GHz map of W3. The peak contour of 25 corresponds to 2.4 K Tb.

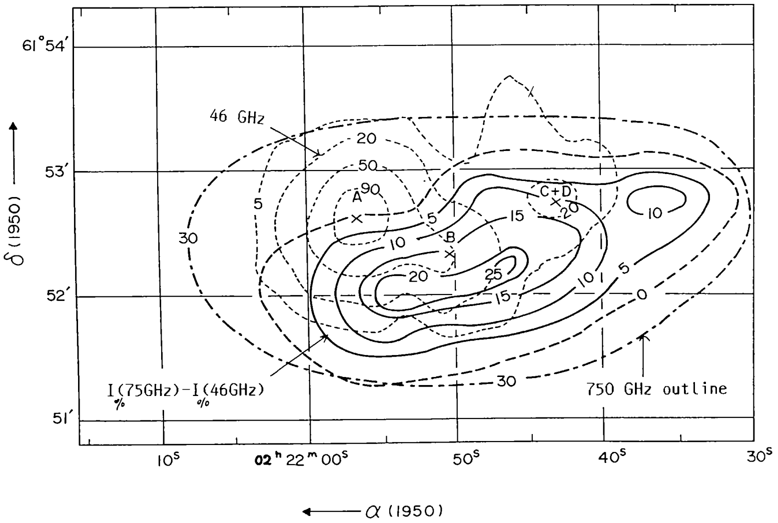

Fig. 3. Excess in the 75-GHz emission over the 46-GHz emission. Contour levels are in percentage of the W3 peak.

A spectrum of the excess brightness over the free-free emission is shown in Figure 4. The spectrum at $\lambda < 1$ mm may be fitted with an optically thin warm dust of 50 K with an optical depth depending on ν as $\tau \propto \nu^2$ and $\tau = 0.02$ at 750-GHz. However, at $\lambda > 1$ mm we have a difficulty to fit the spectrum with this dust component alone. We may therefore introduce a second component so that the observed brightness can be ex-

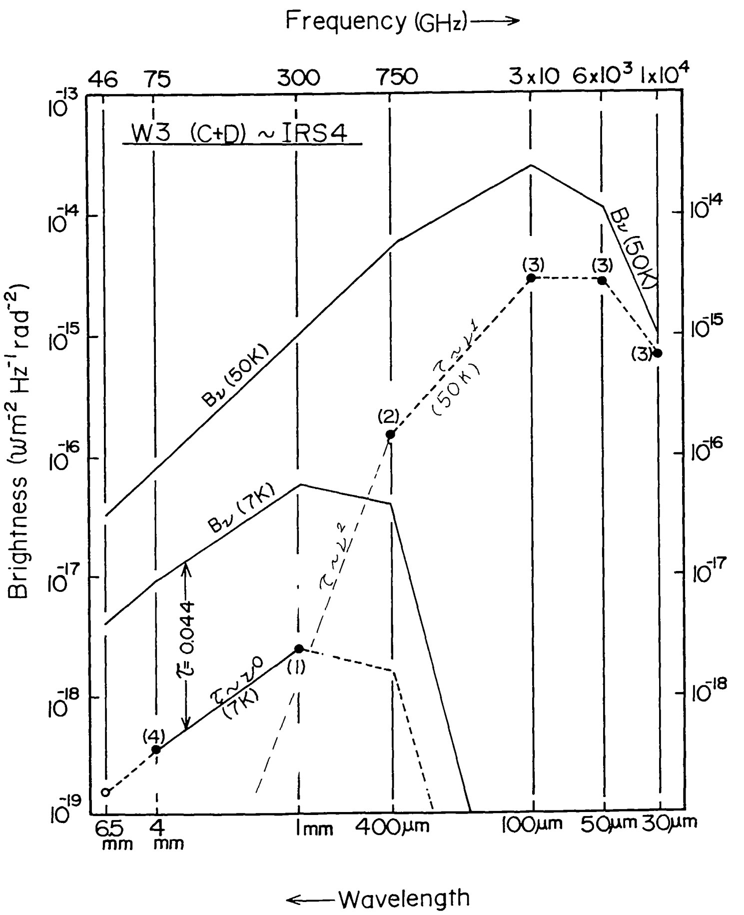

Fig. 4. Intensity spectrum on W3 C+D. The free-free H II emission has been subtracted. Plotted data are: (1) Westbrook *et al.* (1976); (2) Jaffe *et al.* (1983); (3) Werner *et al.* (1980).

pressed as $B(\nu) = \tau_1(\nu)\, B_\nu(T_1) + \tau_2(\nu)\, B_\nu(T_2)$, where τ_i is the optical depth as a function of the frequency and $B_\nu(T)$ represents the Planck's function with T_i the dust temperature. For the first term we have T_1 = 50 K and $\tau_1(\nu) = 0.02\ (\nu/750\ \mathrm{GHz})^2$. The second component can be fitted with T_2 = 7 K and $\tau_2 = 0.044$.

The total luminosity of the 50-K component is L(50 K) $\sim 10^5\ L_\odot$ and the total grain mass is several $M_\odot$; the total gas and dust in the W3 core region is $10^3\ M_\odot$ for a dust-to-gas ratio of 10^{-2} (Jaffe *et al.* 1983). This component is like a typical dust cloud normally found in compact H II regions (Schwartz 1982).

The characteristics of the second 7-K component are unclear. As the frequency dependence is small, $\tau \propto \nu^0$, we may suppose that the particle size is large compared with λ, or a >6 mm. This implies that the material is possibly "stones" rather than grains. The total luminosity of this component is L(7 K) $\sim 4\ L_\odot$. If we assume that the particle radius is $a \sim 1$ cm and density $\rho \sim 1$ g cm^{-3}, the total mass of the stones is $M(7\ K) \sim 4\pi/3\ \rho a^2\ \ L/4\pi a^2 \lambda T^4\ \ \sim 10\ M_\odot$ with λ the Stefan-Boltz-