FLUORESCENT H_2 EMISSION IN THE PLANETARY NEBULAE BD+30 3639 AND HB 12

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ABSTRACT. We report results from a program of near-infrared spectroscopic observations of the H_2 emission from planetary nebulae, being carried out at McDonald Observatory using an InSb array-detector spectrometer. Our observations employ both high spatial resolution (3" diameter aperture) and high spectral resolution ($\lambda/\Delta\lambda$ = 200 -600), thus avoiding potential problems with line blending and spatial registration. These observations provide simultaneous measurements of H I recombination lines and H_2 emission lines, thus accurately defining the relative extent and distribution of the ionized vs. molecular material. One-dimensional cuts through the compact planetary nebulae BD+30 3639 and Hubble 12, taken along east-west and north-south axes through the nebular centers, show that the H_2 emission is concentrated in a ring or shell outside the ionized nebular core. The angular extent of the H_2 emission in Hb 12, with a characteristic diameter of about 8-10" arc seconds, is strikingly larger than the dimensions of the ionized core, which is less than 2" in diameter.

In order to use the infrared H_2 lines to deduce properties of the molecular envelopes such as the gas temperature and total mass, it is necessary that one first establish what mechanism is responsible for producing the observed line emission. The two alternatives are (1) thermal emission (for example, from shocked material), and (2) "fluorescence" or radiative cascades following absorption of UV photons and molecule formation into excited states. These mechanisms can be distinguished by differences in the expected relative line intensities, particularly of lines from high-lying vibrational-rotational levels which will be strong under radiative excitation and weak in the thermal case (e.g., Black and van Dishoeck 1987, *Ap. J.*, 322, 412). We have obtained spectra at the positions of peak H_2 emission in both BD+30 3639 and Hb 12, and find clear evidence for the fluorescence process. In particular, a 2.0-2.3 μm spectrum offset by 4" from the nebular center of Hb 12 shows at least six lines arising from the v = 1, 2, and 3 excited vibrational levels, including a 2.247 μm 2-1 S(1) line which is nearly as strong as the 2.122 μm 1-0 S(1) line. This spectrum is inconsistent with any thermal model, but is matched well by the fluorescence models. We thus conclude that radiative processes are responsible for the H_2 line emission from these particular planetary nebulae.

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