DWARF CARBON STAR MODEL ATMOSPHERES AND SYNTHETIC SPECTRA

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Dwarf carbon (dC) stars are believed to be main-sequence stars which have received carbon-rich material from a former AGB carbon star companion. We have computed model atmospheres, synthetic spectra, and colours for dC stars and compared them with observations. Our models are computed with an updated version of the MARCS code (Jørgensen et al. 1992, A&A 261, 263) and include atomic and molecular line blanketing, grain formation, and collision-induced absorption (CIA) processes (Borysow et al. 1997, A&A 324, 185). The models assume hydrostatic equilibrium, which for giant stars (i.e., high luminosity and low gravity) would be inconsistent with the inclusion of dust. Typical gravities of dC stars are, however, considerably larger than the acceleration due to radiation pressure even on dust grains with a relatively high absorption coefficient.

For the cooler solar metallicity models, grain formation can be substantial, but it depends strongly on the assumed type of dust. In a test model of T_{eff} = 2800 K, C/O = 1.17, and log(g) = 5, 1% of the free carbon (i.e., that not bound in CO molecules) condensed when the dust was assumed to be amorphous carbon, whereas as much as 30% condensed when nano-diamonds (of the extra-solar form which are abundant in carbonaceous chondrite meteorites and are believed to have formed in stellar outflows) were allowed for. This difference in degree of condensation is due to the very small diamond opacity compared to that of amorphous carbon. In both cases, however, the main effect of the dust was a 400 K heating of the surface layers. The dust itself is not clearly visible in the synthetic spectrum, but the heating and correspondingly reduced molecular partial pressures cause a weakening of spectral features in the 3μm region (due mainly to reduced C_2H_2 abundance in the upper layers) and reduced CO fundamental and first overtone band intensities.

For the low metallicity models, collision-induced absorption of H_2–H_2 complexes dominates the opacity. The continuous CIA is strongest at intermediate infrared wavelengths (typically around 2 to 5μm at temperatures of our interest) and causes the near infrared colours to become more blue. For a test model of T_{eff} = 4000 K, $Z = 10^{-4} Z_{\odot}$, and C/O = 1.17, the effect of CIA was a reduction in the value of the synthetic H–K and J–H colours of 0.15 and 0.3 mag., respectively.

The computed features due to C_2, CO, and CN are much weaker in dC stars than in giants of the same T_{eff}, and the H^- opacity minimum hump is almost absent. Polyatomic molecules, on the other hand, form more readily in the dwarfs than in the giants, due to the higher gas density.

The solar metallicity dwarf models occupy the same region of the JHK colour-colour diagram as the giant carbon stars, but the low-metallicity giant and dwarf models are well separated. There is a good agreement between synthetic and observed colours for our giant models of all metallicities, but the computed JHK colours for the low-metallicity dwarfs are bluer than the observed dC stars. Ironically, we are able to fit the observed colours of the dwarfs with less complete opacities in our models. However, our models with what we consider the best available opacity data can fit the colours of the dwarf carbon stars if the stars for example are surrounded by a dusty envelope or disk.

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