Time-dependent Models of Circumstellar Dust Shells

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Carbon-rich Asymptotic Giant Branch stars are sites of dust formation and undergo significant mass loss, at rates ranging from $10^{-7}$ to $10^{-4}$ $M_\odot/yr$. While the shell dynamics and grain formation are closely coupled, most previous circumstellar shell models have treated the problems separately. We present a more complete physical model, solving the dynamics equations of the outflow, modified to include grain formation. Grain formation is modeled using kinetic equations for small cluster growth coupled to moment equations which determine the growth of large particles. The model results indicate that grain formation is a two-stage process, with large grains forming close to the photosphere (within about 1 stellar radius), and evaporating to much smaller sizes as they are accelerated by radiation pressure into lower density regions. As this gas cools, additional small grains form. The velocity structure of the circumstellar shell consists of a number of shocks corresponding to bursts of grain formation. The density distribution of gas in the outflow is dragged by the grains into a flat, power law like distribution.

We have examined the effect of different [C]/[O] ratios, stellar temperature and stellar luminosity. The models demonstrate that higher values of [C]/[O] result in higher mass loss rates, with an order of magnitude change in condensable carbon availability resulting in up to a factor of 5 increase in mass loss rate. This is due to the formation of larger grains which sustain higher outflow velocities. Increasing stellar temperature also results in higher mass loss rates. However, when holding other quantities equal, models with higher stellar luminosities yield lower mass loss rates, due to the smaller grains formed around high luminosity sources. This is not incompatible with observations, since higher luminosity sources generally have higher carbon abundances, which allow the observed increase in mass loss rate.

15.04

On the Weakness of C I and O I Resonance Line Emission from the Chromosphere of α Ori

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The resonance lines from multiplets UV 2 of both O I and C I are typically quite strong in emission in the far-UV spectrum of cool stars. However, in the prototypical M-supergiant α Ori, these lines are remarkably weak, although other transitions from the same upper energy levels, O I (UV 146) and C I (UV 32), are observed in strong emission despite their much weaker intrinsic strengths. Due to the presence of many lines from other species in the regions around the UV 2 multiplets of O I and C I near 1302 Å and 1655 Å, the lines of interest suffer severe blending and progress in understanding this flux deficiency is difficult based on low resolution IUE and GHRS data. We have therefore obtained medium resolution (R=10,000) GHRS spectra of α Ori of these complex spectral regions, as well as the regions around the O I (UV 146) and C I (UV 32) lines near 1640 Å and 1993 Å, respectively, to resolve the various contributors and allow detailed study of this phenomenon. In this paper, we present the spectra and discuss the formation of the O I, C I, Fe II, and S I lines which they clearly resolve. Semi-empirical modeling of the outer atmosphere of α Ori and detailed radiative transfer calculations are used to study the creation and destruction of O I and C I photons.

15.05

Measurements of Starspot Area and Temperature on II Pegasi

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We are developing an empirical technique that yields independent measurements of starspot area and starspot temperature on active stars. Our technique involves fitting observed spectra near TIO absorption bands with synthetic spectra derived for various combinations of starspot and non-spot temperatures and...