The Homunculus: a Unique Astrophysical Laboratory

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Abstract

In the 1840s, Eta Carinae underwent a massive ejection, repeated to a lesser extent in the 1890s. Today we see the Homunculus, an expanding bipolar neutral structure expanding outward at 500 km/s with a more slowly moving, internal bipolar ionized structure, the Little Homunculus. The central source is found to be a massive binary stellar system with a 15000 K primary star with a hot, O or WN companion in a highly elliptical 5.54 year orbit. The system is ideal as an astrophysical laboratory for absorption and emission line spectroscopy. In the line-of-sight, multiple narrow line absorption components are observed with densities around 10^7 cm^{-3} and temperatures ranging from 760 to 6400 K at 10,000 and 1300AU distance from Eta Carinae, respectively. Thousands of metal lines are identified, plus molecular hydrogen, CH, OH, NH and likely other molecules. The Strontium Filament, a truely unique emission nebula located in the skirt region between the bipolar lobes, is found to be a neutral emission gas excited by photons with energies below 7.9 eV (Fe II ionization potential), No hydrogen, helium or nitrogen emission is associated with this structure thought to be excited by Balmer continuum from the central source. For most of the spectroscopic cycle, bright emission blobs and the Little Homunculus are highly excited, but relax for a few months during the periastron passage. During this short period of time, spectral lines in [Ar III].[Ne III], [Fe III], [Fe IV] and Lyman alpha continuum-pumped Fe II and Cr II emission lines disappear due to a cut-off in UV-radiation. Given the changes in spectra, we are learning not only about the binary system and its ejecta, but in turn can use this system to test atomic spectroscopy. Examples that can be presented include the greatly improved Cr II curve-of-growth, based upon new experimental atomic data sets, improved V II wavelengths due to inconsistencies in the velocity measures that correlated with energy levels. Problems we continue to face include transition probabilities for Fe I, lifetimes of metastable states of many iron peak singly ionized species, limited atomic data on Ca II and Sr II, and indeed understanding the effects in a nitrogen-rich, carbon

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poor gas. Finally we note that the recent GRB high dispersion spectra demonstrate local ejecta of GRB progenitors are relatively hot, photoexcited gases (which include detectible oxygen and carbon). The studies of the Eta Carinae ejecta are proving to be invaluable for interpreting these new and exciting results.

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