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## Cas A's Carbon Recombination Lines: A Model That Works

H.E. Payne (STScI), K.R. Anantharamaiah (RRI), W.C. Erickson (U.Md)

When carbon recombination lines were first detected towards the Cassiopeia A supernova remnant, they held promise as a powerful new probe of conditions in the cold neutral ISM, especially if they originate in the same gas as the neutral hydrogen $\lambda$21 cm absorption lines. This promise has gone largely unfulfilled, in part because of the limited success of modeling the line emitting clouds in the observationally ideal case of Cas A. Lines have been detected at more than twenty frequencies between 14.7 and 770 MHz, providing a modeling challenge.

We recently examined systematic effects in this large body of data and derived new corrections, but still found that existing models result in unphysically high pressures and conditions far from thermal balance.

We calculated a new class of models based on work by Gulyaev and Nefedov (1989, Astron. Nachr., 310, 403). These models change the assumptions about the behavior of carbon atoms as the principal quantum number $n$ becomes large. Instead of assuming an infinite number of levels, populated according to thermodynamic equilibrium, these new levels assume that since the atoms are more likely to be ionized by passing electrons as $n$ increases, levels above a certain $n$ will be empty. This cutoff value of $n$ is decreased if the electron density is raised.

When we fit these new models to the Cas A data, we find that there are models with reasonable pressures, and where the clouds are in a stable thermal balance. One of the results of this modeling is that the physical temperature is well below the derived $\lambda$21 cm spin temperature.