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Physical Conditions and Abundances in NGC 6543

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1. Introduction

We present analysis of the physical conditions and chemical abundances in NGC 6453, the Cat's Eye Nebula. Using archival *HST* images in conjunction with ground-based long-slit scanning spectra, we have produced an [O III] forbidden line temperature map of the nebula, which shows that the temperature remains constant at around 8000 K across the nebula. From the long-slit spectra, we have determined abundances both from collisionally excited lines (CELs) and optical recombination lines (ORLs). The ORL abundances are higher than the CEL abundances by a factor of approximately two.

2. Analysis

An extinction map of NGC 6543 was produced from the F487N (Hβ) and F656N (Hα) images, by comparing the observed ratio in each pixel to the theoretical value. The reddening is low, with an average logarithmic extinction at Hβ, $c = 0.1$, and exhibits only small spatial variations. Consequently, all images were dereddened using a constant c value of 0.10.

Using images taken in *HST* filters F437N ([O III] λ4363) and F502N ([O III] λ5007), a temperature map was produced. The [O III] λ4363 is weak, and the filter bandpass contains significant nebular continuum emission as well as contributions from Hγ λ4340 and He I λ4388, which must be corrected for. For this purpose, we have made use of the theoretical continua from Brown & Matthews (1970), He I recombination coefficients from Benjamin, Skillman & Smits (1999) and H I recombination coefficients from Storey & Hummer (1995) together with filter profiles from the IRAF task *bandpar*. The predicted nebular continuum level is further constrained using our long-slit spectrum. The correction was calculated in terms of the flux of Hβ only, as the ratio of images F487N & F588N is virtually constant across the nebula. The correction applied was, I([O III] λ4363) = F437N$-0.032\times$F487N. The F502N image is dominated by the strong [O III] λ5007 line, thus continuum contamination is negligible.

By comparing the ratio of [O III] λ5007 & λ4363 emission in each pixel, a temperature map was produced, shown in Figure 1 as a contour map with contours at 500K intervals between 7000 and 8500K, overlaid on an *HST* F502N image. The temperature averages about 8000 K, and varies little across most of the surface of the nebula. This value agrees well with the results from our long-slit scanning spectra discussed below.

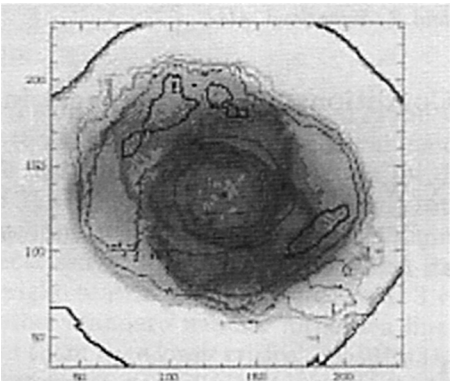

Figure 1. [O III] temperature contours overlaid on [O III]λ5007 image

Hyung et al. (2001) have also produced a temperature map of NGC 6543 from the same archival *HST* images. They derive a higher temperature of 9000 K for the core of the nebula, and find that the temperature rises considerably at the outer edge of the core. We find that the temperature remains reasonably constant up to 15″ away from the central star. Beyond this we do not believe the signal to noise ratio of the F437N image is high enough to derive an accurate temperature. These differing results may be due to different treatments of the F437N image. Hyung et al. did not correct their [O III] λ4363 flux for Hγ or He I λ4388 emission. We find that these corrections are not negligible, amounting to 30% of the total correction (which accounts for 53% of the flux in F437N). Also, their continuum correction was derived using Echelle spectra of two small regions of NGC 6543, while ours is based on a spectrum of the entire nebula.

Optical, IUE and ISO spectra of NGC 6543 were analysed. The optical spectra were obtained at the WHT 4.2m telescope with the ISIS double spectrograph, by uniformly scanning a long-slit across the nebula, thus yielding average spectra for the whole nebula. The Balmer jump and [O III] temperatures agree very well, at 8340 K and 7940 K respectively. From the standard diagnostics a temperature of 8000 K and a density of 5000 cm^{-3} were adopted. Abundances were calculated from both ORLs and CELs: the results are shown in Table 1.

Table 1. Ionic Abundances in units such that $\log N(\mathrm{H}) = 12.0$

	He	C	N	O	Ne	S	Ar	Cl
ORLs	11.07	8.89	8.77	9.12	8.74			
CELs		8.46	8.60	8.91	8.47	7.15	6.50	5.41

References

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