Chapter 7

Spectroscopy of HD 168625

7.1 Abstract

In this chapter we have analysed the high resolution optical spectra of HD 168625 and derived the atmospheric parameters and the chemical composition. We obtained $T_{\text{eff}}=15000\,\text{K}$, $\log g=2.5$ and $[\text{M/H}]=0.0$, and estimated the chemical composition. HD 168625 has large nitrogen abundance and very large neon abundance. The oxygen abundance is solar. Carbon is depleted. Magnesium, silicon and sulfur also has low abundance. The large neon abundance could be due to NLTE effect.

7.2 Introduction

HD 168625 (also V4030 Sgr) is classified as B9-A0 supergiant by Morgan et al. (1955). It is an IRAS source with far-IR colors similar to planetary nebulae and post-AGB stars. Its evolutionary status is not clear. The circumstellar dust shell indicates that it has experienced mass loss in the recent past. High resolution spectroscopy may enable us to understand the evolutionary status of this star. It is known to be in the
close proximity to HR Car in the HR diagram, and at the low luminosity end of the luminous blue variable (LBV) region. LBVs are extreme supergiant stars. They are generally thought to represent a short-lived intermediate stage in the evolution of massive stars from O to Wolf-Royet (WR) stars (c.f. reviews by Humphreys 1989; Hiller 1992; Wolf 1992). About ten LBVs are known in our Galaxy. LBVs are characterized by the high variability in their temperature, radii and in the mass loss properties. They also display irregular photometric variations over timescales of decades. They appear to move (at const. bolometric luminosity) from hot, visual minimum phase ($T_{\text{eff}} = 20000\text{-}30000\text{K}$) across the upper luminosity boundary to a cooler ($T_{\text{eff}} < 10000\text{K}$) visual maximum phase, where they develop false photospheres and typically resemble very luminous A-type supergiants. No major spectrophotometric variations has been observed recently for HD 168625 to classify it to be a LBV. But there are also LBVs which have long periods of quiescence like PCygni and η Carinae.

Assuming the membership of M17 complex in Sgr OB1 association, HD168625 is placed at a distance of 2.2kpc. From this the corresponding $E(B-V) = 1.46$, $M_{\text{bol}} = -8.6$ are found. This places it close to HR Car and at the low-luminosity end of LBV region.

In this work we have investigated the evolutionary status of HD 168625 from the high resolution optical spectrum and on the basis of the chemical composition.

### 7.3 Observations and analysis

High resolution spectrum was obtained using the 2.5m Isaac Newton Telescope (INT) located at La Palma, which is equipped with a Intermediate Dispersion Spectrograph (IDS). The observations were made on 24th May 1991. The spectra covers wavelength regions 5325-5450Å, 6125-6225Å, 6300-6400Å, 6525-6625Å, 7060-7175Å, 7400-7500Å and 8680-8780Å. It has a resolution of 0.3Å at 6000Å. The data is reduced using the IRAF software. The wavelength calibrated normalized spectra is compared with
theoretical spectrum. The theoretical spectrum is calculated using the SYNSPEC code by Hubeny (1986). We had used the Kurucz (1993) model atmospheres. The linelist for the spectrum synthesis is taken from the Kurucz lineslist (1993).

7.4 Results

The high resolution optical spectrum of HD 168625 show absorption lines of CIi, NIi, OII, MgII, SiII, SiII NeII and HeI. From the SiII lines we estimated a temperature of 15000K and log g=2.5. The long slit spectra shows an extended emission in Hα and also in [NIi] 6548, 6583Å lines (Fig. 1). This indicates an extened nebula around the star. The spectra also shows lot of strong diffuse interstellar bands (DIBs). The estimated chemical composition is listed in Table.1

From the spectrum synthesis (Fig. 2), we found that the nitrogen abundance is enhanced and the neon abundance is quite high. The oxygen abundance is solar. The
Table 1: Chemical composition of HD 168625.

<table>
<thead>
<tr>
<th>[element/H]</th>
<th>[C/H]</th>
<th>[N/H]</th>
<th>[O/H]</th>
<th>[Mg/H]</th>
<th>[S/H]</th>
<th>[Si/H]</th>
<th>[Ne/H]</th>
</tr>
</thead>
<tbody>
<tr>
<td>T_{eff}=15000K</td>
<td>-0.34</td>
<td>0.52</td>
<td>0.0</td>
<td>-0.3</td>
<td>-0.46</td>
<td>-0.57</td>
<td>0.8</td>
</tr>
<tr>
<td>log g=3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sulfur and silicon abundances are low. We have obtained the IUE NEWSIPS data from Vilspa. From the UV spectrum we derived E(B-V)=1.4. From the Hipparcos parallax (2.49 mas) for HD 168625, and (B-V)=1.227, V=8.96 we derived, a distance of 401.6 pc and estimated M_v=-4.1, (B-V)_0=-0.173. This places the star to be B5II.

7.5 Discussions

The spectral type of HD168625 seem to vary between B2 (Popper & Seyfert 1940) to A0 (Morgan et al. 1955) and B5.6 (Chentsov & Lund 1989). The equivalent widths of the lines are also seem to vary. So the derived abundance assuming a static atmosphere should be taken with a caution. The enhancement in the nitrogen abundance seen in HD168625 is consistent with the nitrogen rich nebula. This also gives an evidence that the nebula has formed from the material ejected from the CNO processed stellar surface.

The distances derived from the Hipparcos parallax seem to be inconsistent with the previous results. The distance 0.4kpc from the Hipparcos measurement is very less than the distance of 2.2kpc, assuming that HD 168625 belongs to the Omega nebula. The reddening derived from the nebular lines show E(B-V)=0.75, which is less than 1.4 which is derived for the star. This indicates that HD 168625 is further away from the Omega nebula. Further evidence came from the velocity shifts of NaI D lines, which show higher positive shift compared to HD 168607 which is a nearby LBV in the Omega nebula.

There is still a possibility that the excess reddening of the star light compared to
the nebula is probably due to large dust grains around the star. The near IR imaging gives evidence for such a possibility of having larger grains. It appears, HD 168625 is a relatively be a star with a cool dusty disk.

From the Hα line emission a gas mass of 0.1\(M_\odot\) is derived assuming a distance of 2.2 kpc. This is found to be less if HD 168625 has to be a LBV. But if one assumes a distance of 0.4 kpc then the mass will be around 0.01\(M_\odot\). Also the morphology of the nebula around HD168625 is peculiar. The [NII] lines indicate the presence of a low excitation nebula. This is typical of planetary nebulae. The enrichment of nitrogen in the nebula as well as in the star shows that it is an evolved star. But we also see very high enrichment of neon in the star. But the surrounding nebula does not seem to show any nebular lines of neon.

There are lot of unidentified IR lines and also DIBs seen in the spectra. Generally the origin of these lines are thought to be the Poly Aromatic Hydrocarbons (PAHs). These are strong in the cases where the C/O high. But we see enriched nitrogen. So more detailed study is needed to know about the origin of these features.

The evolutionary status of HD168625 is not clear. It may be a LBV or a post-AGB star with a core mass of the order 1.0 \(M_\odot\). The overabundance of nitrogen is similar to that observed in type I planetary nebulae. Accurate distance is needed to estimate the absolute luminosity of HD 168625. The LBV star HR Car also shows overabundance of nitrogen. The right underabundance of sulphur in HD168625 indicates that it may be slightly metal poor. The variations in the spectrum and overabundance of nitrogen, low galactic latitude are more consistence with the interpretation that HD168625 is a LBV.