5.4.1 Periodical behaviour and characteristics of *HeI* λ6678

HeI λ6678 is one of the lines other than H_α that has been monitored by the group of professional and amateur astronomers of BeSS since 2007 for the periastron passage, which occurred in July 2011 (Tycner, 2011). Usually, this line is observed together with the H_α line. The emitting disc radii of this element have been measured as much smaller than the lower Balmer line Hγ and therefore, this emission line always appears in a double-peaked profile.

From four consecutive years of observations: 2007, 2008, 2009 and 2010, we found that *V/R*< 1 for 2007; then, for the first half of 2008 *V/R* was observed >1 but it decreased towards the end of 2008 when *V/R* became<1. In 2009, *V/R* was noticed as>1 and in 2010, it showed both signs but in the opposite manner of 2008. Figure 5.14 (top) shows the variation of *V/R* with time. We estimate that the period of *V/R* variation of this emitting region is about 480 days, by considering the period from peak to peak of *V/R*. Figure 5.14 (top) also shows the correlation of the variation of radial velocity and *V/R* ratio with time. Both parameters are inversely related, that is, the radial velocity is increasingly shifted towards longer wavelength with decreasing *V/R* ratio. The range of radial velocity of *HeI* λ6678 increased from about ±50 km/s in 2007 to about ±150 km/s in 2009 and apparently decreased in 2010, which for most of the time the line exhibited a red shift.

Analysis of the line strength shows that the values of *EW* have been gradually decreased except for the data from 29th May 2009 (refer to Table 5.3), which show an increment by about three times over the previous data.

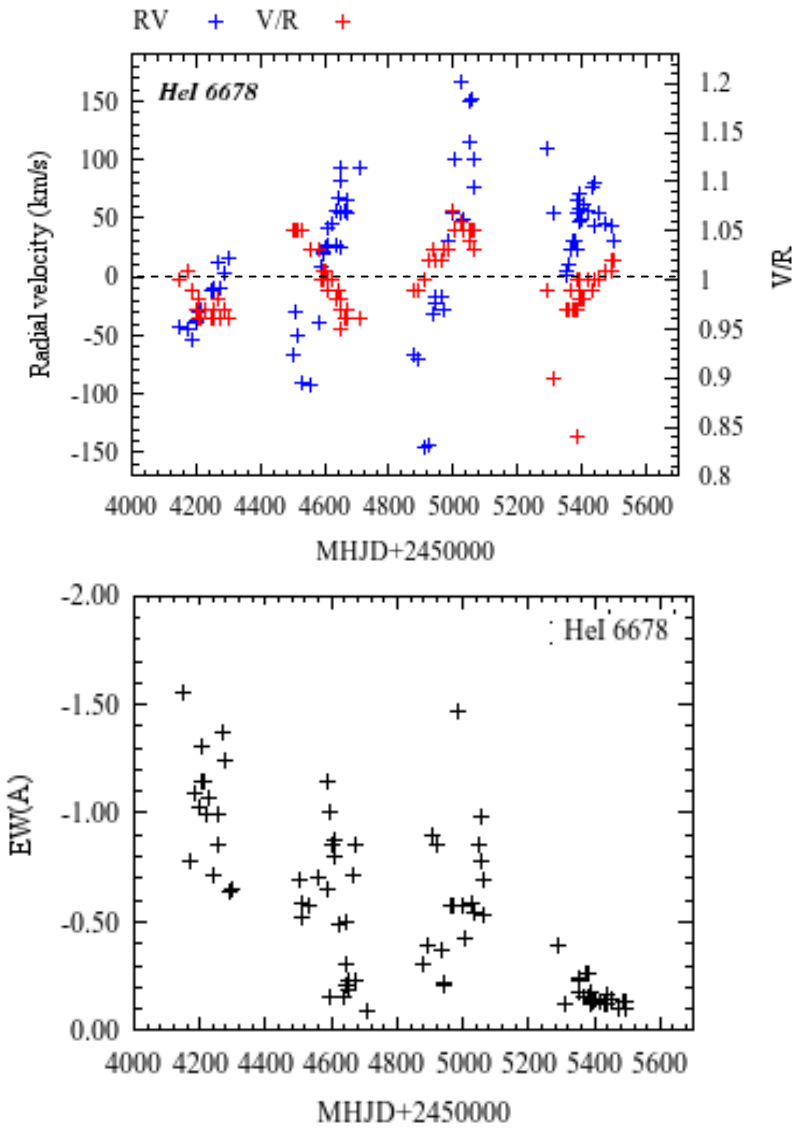

Figure 5.14 – Correlation of radial velocity (*RV*) and *V/R* variations with time (top) and the variation of *EW* of *HeI*λ6678 with time from 2007 to 2010 (bottom).

There were no data taken on the following days and thus, there was no information on how long the line held such strength. Nevertheless, we did an inspection on the features of the line profile for a few days before and after the apparent increment, as shown in Figure 5.15. We show that the red peak exhibited a bulge on its blue side on the 9th and 29th May 2009 before the line profile displayed a triple-peak profile, where the third peak appeared in between the violet and red peaks and it appeared to move around in between those peaks.

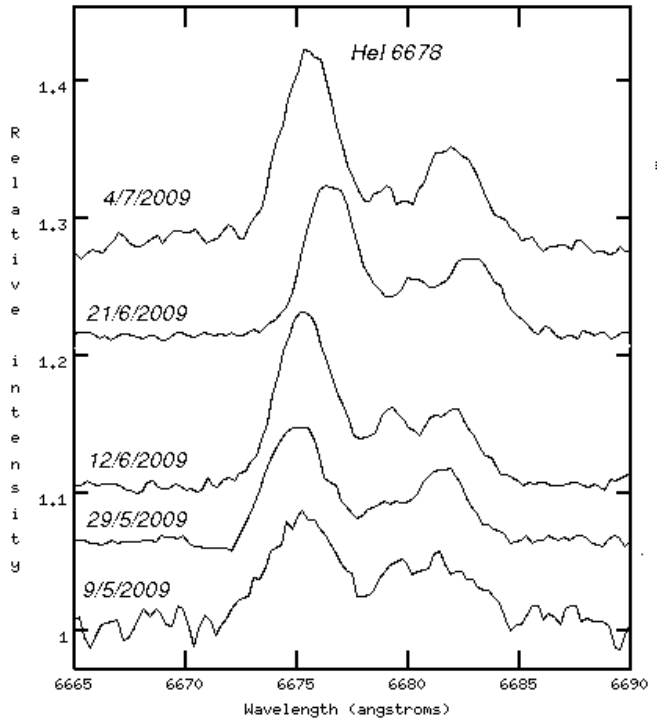

Figure 5.15 – Evolution of triple-peak profile of HeIλ6678.

The other apparent characteristics or behaviours of the *HeI* λ6678 emission line that we detected are the triple or multiple peaks and anomalous profiles. The triple- or multiple-peaked profile was observed clearly in 2009, where a rather small but significant bump appeared in between the violet and red peaks (Figure 5.16a and 5.16b). We observed that this bump moved closer to the violet or red peak before the peak of interest resembled a double-peaked profile.

We also recognised that the line profile sometimes appeared with such an anomalous feature. The features that we observed were a 'shoulder' structure, which formed on either/both sides of the peaks; on August 30th 2008 and April 24th 2010 the profiles resembled a P-Cygni profile but with a slight difference to the classic one. The classic P-Cygni profile consists of a broad intense emission line with a less intense and narrower absorption line displaced to the blue side of the emission line. These profiles

are illustrated in Figure 5.17a and 5.17b. The additional peak which appear in between V and R peaks and the anomalous feature are of the subfeatures travelling through the line profile. These are the typical behaviour of non-radial pulsation. The variations of subfeatures suggest the occurring and travelling of hot regions on the photospheric surface.

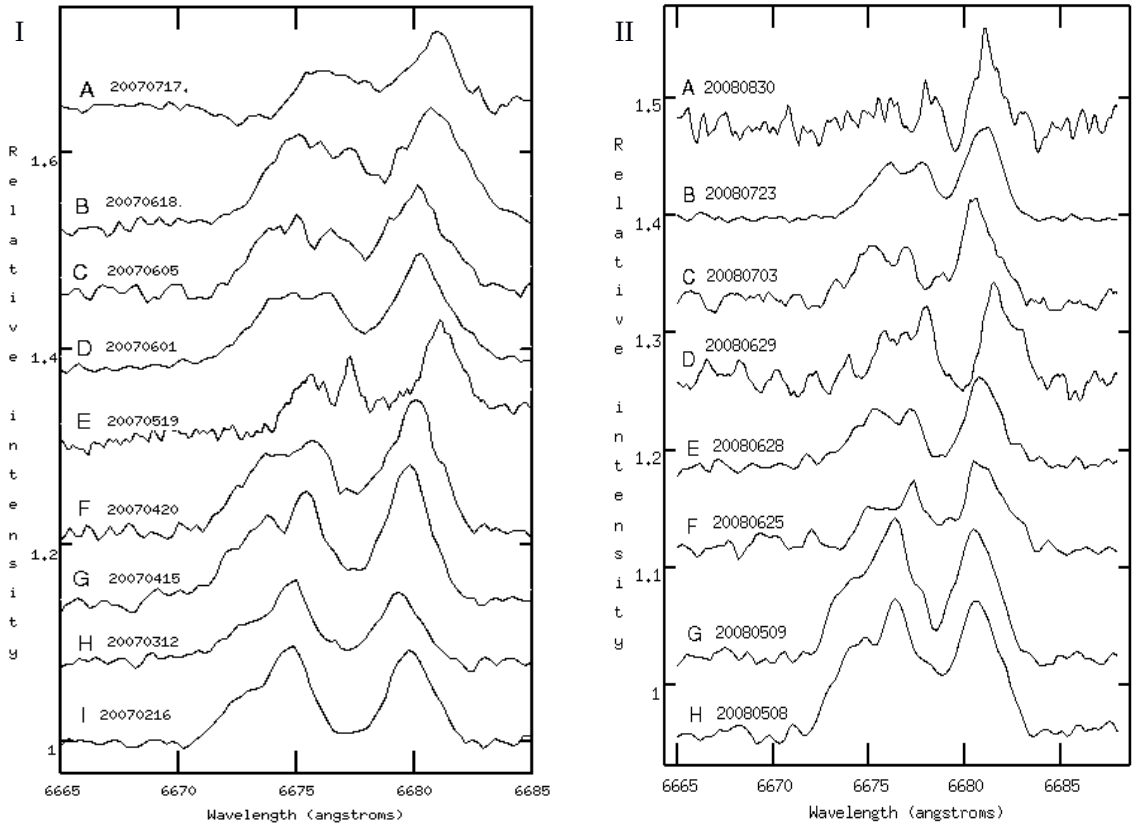

Figure 5.16(a) – Triple-or multiple-peaked and anomalous profiles of *HeI* in 2007 (panel I) and 2008 (panel II). The violet peak profile inpanel I (A to E and G) and panel II (A to E) had a feature like a double or multiple peak, whereas panel I(F,H and I) and panel II (F to H) show a 'shoulder' structure on either side of the violet or red peak.

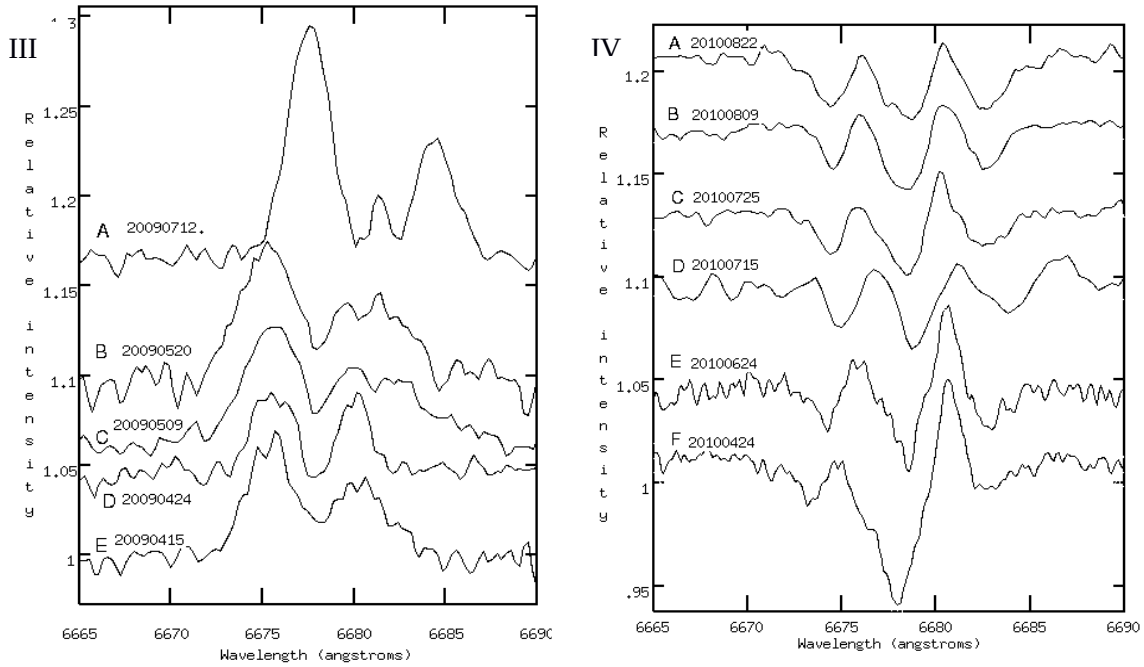

Figure 5.16(b) – The variety of features of *HeI*λ6678 line profile in 2009 (panel III) and 2010 (panel IV). The line profiles of panel III (A and B) show a triple-peaked profile and panel III (B and C) show a 'shoulder' structure on the right side of the red peak. Each peak of the line profiles in panel III(D and E) hadsplit. Panel IV shows the line profiles in 2010,which had reduced in their intensity; the 'shoulder' structure (bulging) appeared on the right side of the red peak in panel IV (C and D) and panel IV (F) shows the profile that resembled the P-Cygni profile.

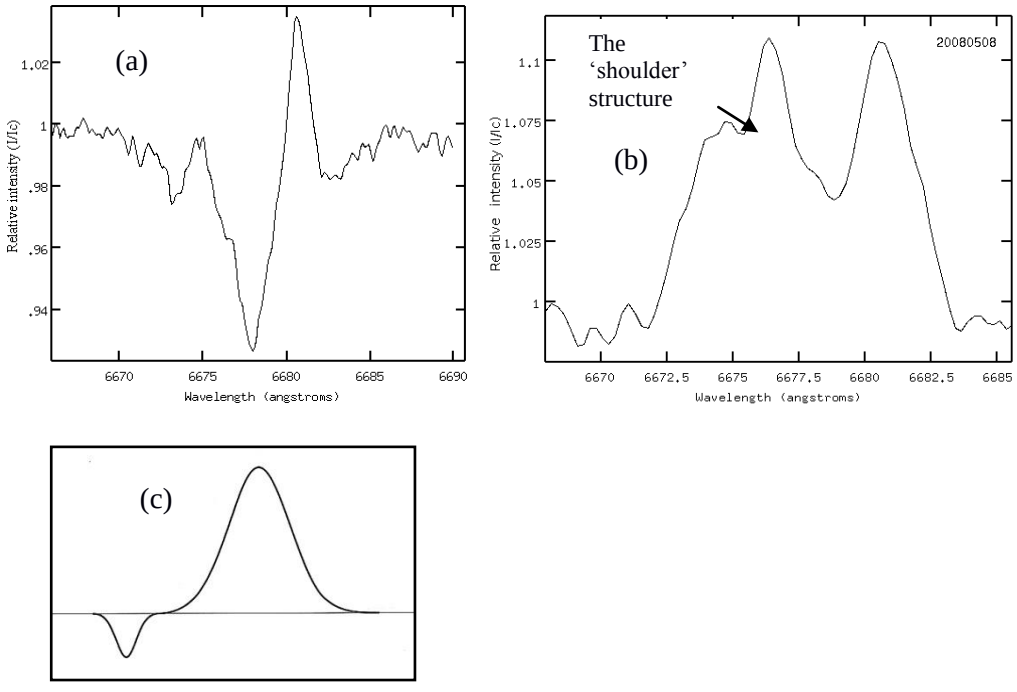

Figure 5.17 – (a) The P-Cygni profile, (b) The 'shoulder' structure, (c) The classic P-Cygni profile.