5.3.2 *V/R* variation

The ratio of violet to red peaks can only be obtained if the line profile shows a double-peaked feature. Figure 5.9 shows the *V/R* variation of H_α of our program star from 2007 to 2010. We show that H_α had *V*>*R* for most of the time. We also noticed that the double-peaked profile usually appeared with *V*>*R* characteristics and with ratio values as high as ~1.4,whereas the *V*<*R* profile was found on very few occasions with a lower ratio value of ~0.9.

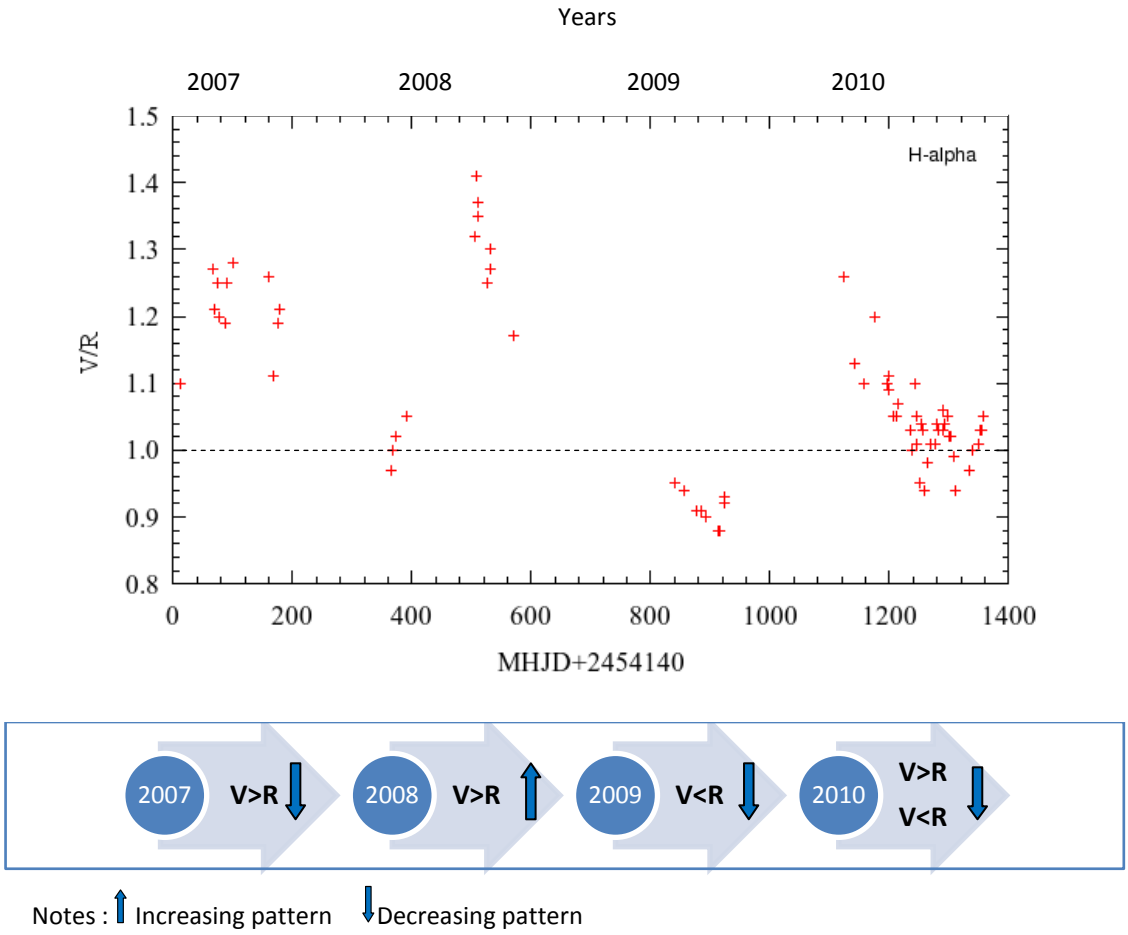

Figure 5.9 – *V/R* variation of H_α from 2007 to 2010. The *V/R*=1 line is drawn to show the boundary of *V*>*R* and *V*<*R* regions. The flow diagram below outlines the change of *V/R* ratio from 2007 to 2010, which is noted by the increasing and decreasing pattern.

The investigation of *V/R* variation was also performed on other Balmer lines: H_β and H_γ . The comparisons of the *V/R* variation among the H_α, H_β and H_γ lines are shown in Figure 5.10. Data for H_β are only available in the BeSS database starting from 2008

and for H_γ they are only available from 2009, when the observation were carried out using an Echelle type spectrograph, which covers the wavelength range from 4274 to 7119 Å with spectral dispersion of about 0.1 Å/pixel. The spectra of δ-Sco have been collected continuously since 2007 and the star will go through the periastron passage in July 2011. Table 5.2 tabulates the list of data and characteristics of the H_β and H_γ lines' profiles.

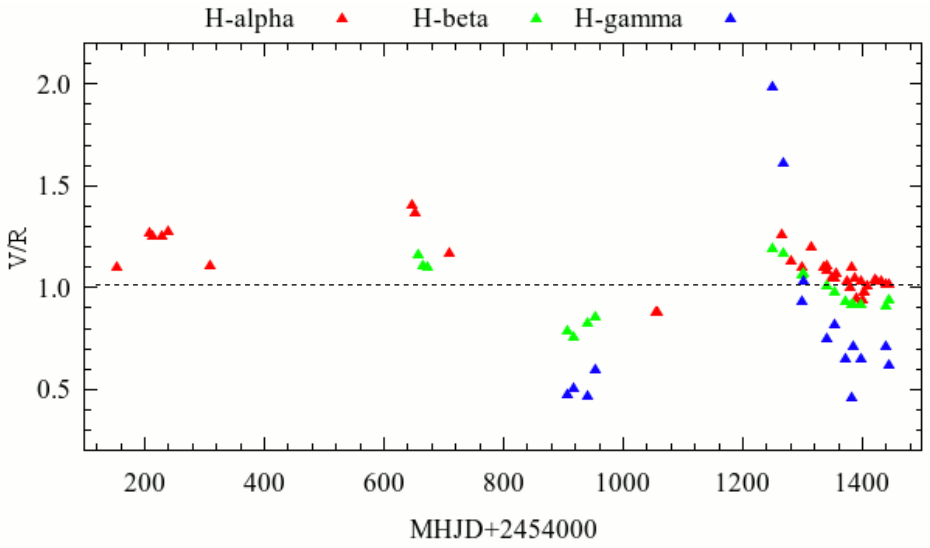

Figure 5.10 – *V/R* ratio of H_α, H_β and H_γ of δ-Sco from 2007 to 2010. The line *V/R*=1 is drawn to show the amplitude of the ratios.

In Figure 5.10, a line is drawn at *V/R* = 1 to make a border for *V*>*R* and *V*<*R* ratios. We found that H_γ had the highest and the lowest *V/R* ratio, i.e., 1.99 and 0.46, respectively, whereas H_α and H_β had ratio values in between those; the highest and lowest being 0.95 to 1.41 and 0.76 to 1.19, respectively. In the H_α region, the ratio of *V*>*R* was observed more frequently than *V*<*R*, whereas in the H_γ region, the pattern was reversed; the ratio of *V*<*R* was commonly observed compared with *V*>*R*. One of the reasons for this inconsistency is that in 2009 or MHJD+2454000[800 to 1000], the H_α line does not appear as a double-peaked profile but as an asymmetric single-peak; thus, no data have been recorded for the *V/R* ratio for H_α. We believe that the asymmetric

single-peak profile of H_α or possibly the unresolved double-peak profile has a relationship with the disc size or radius. From eq.(5.2), as the relative disc radius increases, the double-peaked separation becomes closer relative to the spectrograph's resolving power. Therefore, we expect during this period that the disc's size of H_α emitting region becomes larger in such a way that the instrument's resolving power cannot resolve the double-peaked feature, or it could also possibly be that the disc of the emitting region had grown or fully developed, which deformed the thin disc structure into an extended disc structure.

For H_γ, the values of *V/R* ratio were observed mostly <1 and the intensity of the red peak usually appeared higher than that of the violet peak. However, in the beginning of 2010, the violet peak was observed much higher than the red and in fact, the ratio became the highest compared with H_α and H_β. From Tables 5.1 and 5.2, the values of the *V/R* ratio of H_α, H_β and H_γ for data taken on 21st Feb 2010 were 1.19, 1.19 and 1.99, respectively. The difference of the V/R ratio in those particular regions is supposed due to the difference in the density distribution of each emitting region. Figure 5.10 also shows the amplitude of each emitting regions with respect to the V/R = 1 line. One may see that the amplitude of V/R variation is smaller in H_α and getting larger for H_β and H_γ lines. We know that the optical depth of H_α is higher and smaller in higher member i.e H_β and H_γ, which indicates that the emission lines of higher members are formed in the deeper layers in the disk than that of lower members.

A detailed analysis on the relationship between the *V/R* ratio and the relative disc radii *Rd/R** of the Balmer emitting regions for the star was also carried. The relative disc radii are calculated from eq.(5.2) with the rotational velocity $v \sin i$ = 165 km/s (Helmut, 2002). Figure 5.11 shows the correlation of the *V/R* ratio and the disc

radii relative to the stellar radii. We found that in the H_α and H_γ emitting regions, *V/R* ratios are inversely related to the relative disc radius; a higher *V/R* ratio corresponds to a smaller disc, whereas in the H_β emitting region, the correlation of *V/R* ratios and the relative disc radii is not clear. However, one of the correlations that can be deduced is the amplitude of V/R higher for smaller disk radii.

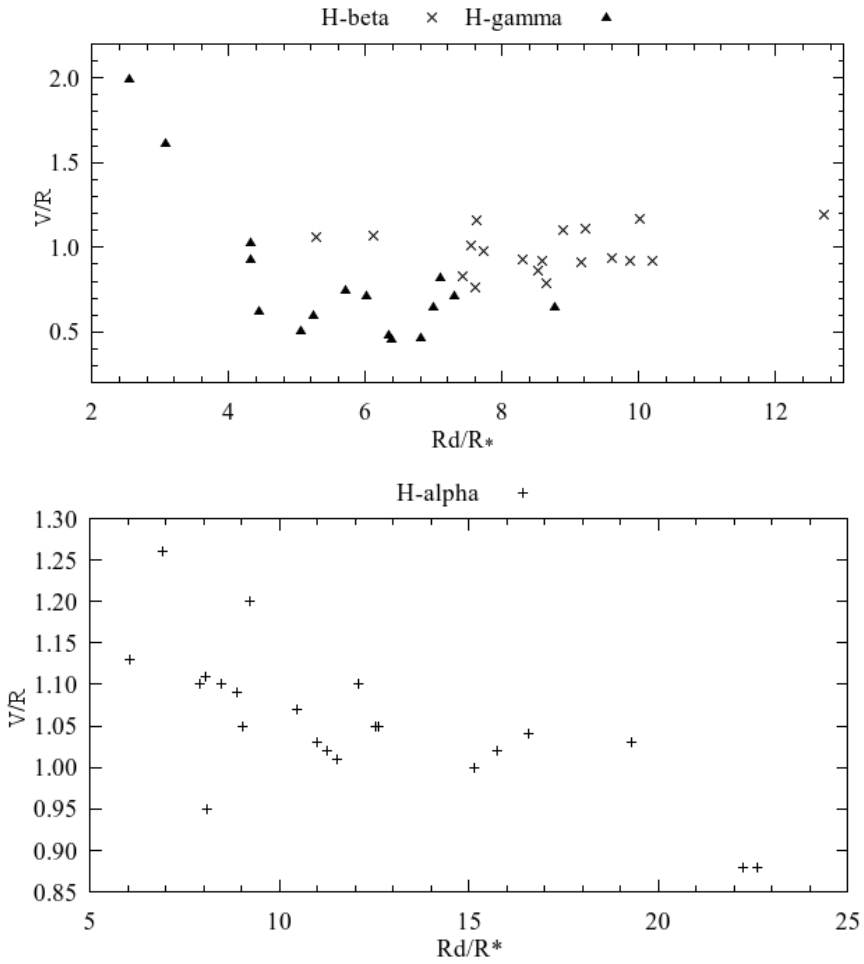

Figure 5.11 – Correlation of *V/R* and the relative disc radii of H_β and H_γ (above) and H_α emitting regions (below) from 2009 to 2010.

In Figure 5.12, we present the variations of the *V/R* ratio of the Balmer line profiles: H_α, H_β and H_γ, which were observed continuously from February to September 2010. We observed that H_α always had the violet peak higher than the red peak. From February to April, the violet peak was found higher than the red peak for all the lines. In

addition, in February and March, only the violet peak was noticeable; the red peak just appeared as a small bump on a kind of shoulder shape. However, for this study, we still considered this bump as the red peak and thus, the *V/R* ratio of this period had the highest value of H_β in 2010 and the relative disc size of this emitting region for that period was about 13R*. In the following month, the red bump clearly evolved and became a peak with $V>R$. The red peak then evolved continuously. In May, the double peak of H_β appeared with $V\approx R$, whereas the H_α and H_γ double peaks showed $V>R$ and $V<R$ characteristics, respectively. Then, starting from June until the end of the observation session in 2010, the double peak of H_β and H_γ turn up with $V<R$, whereas $H_\alpha$displayed a $V>R$ profile but with a decreasing ratio.

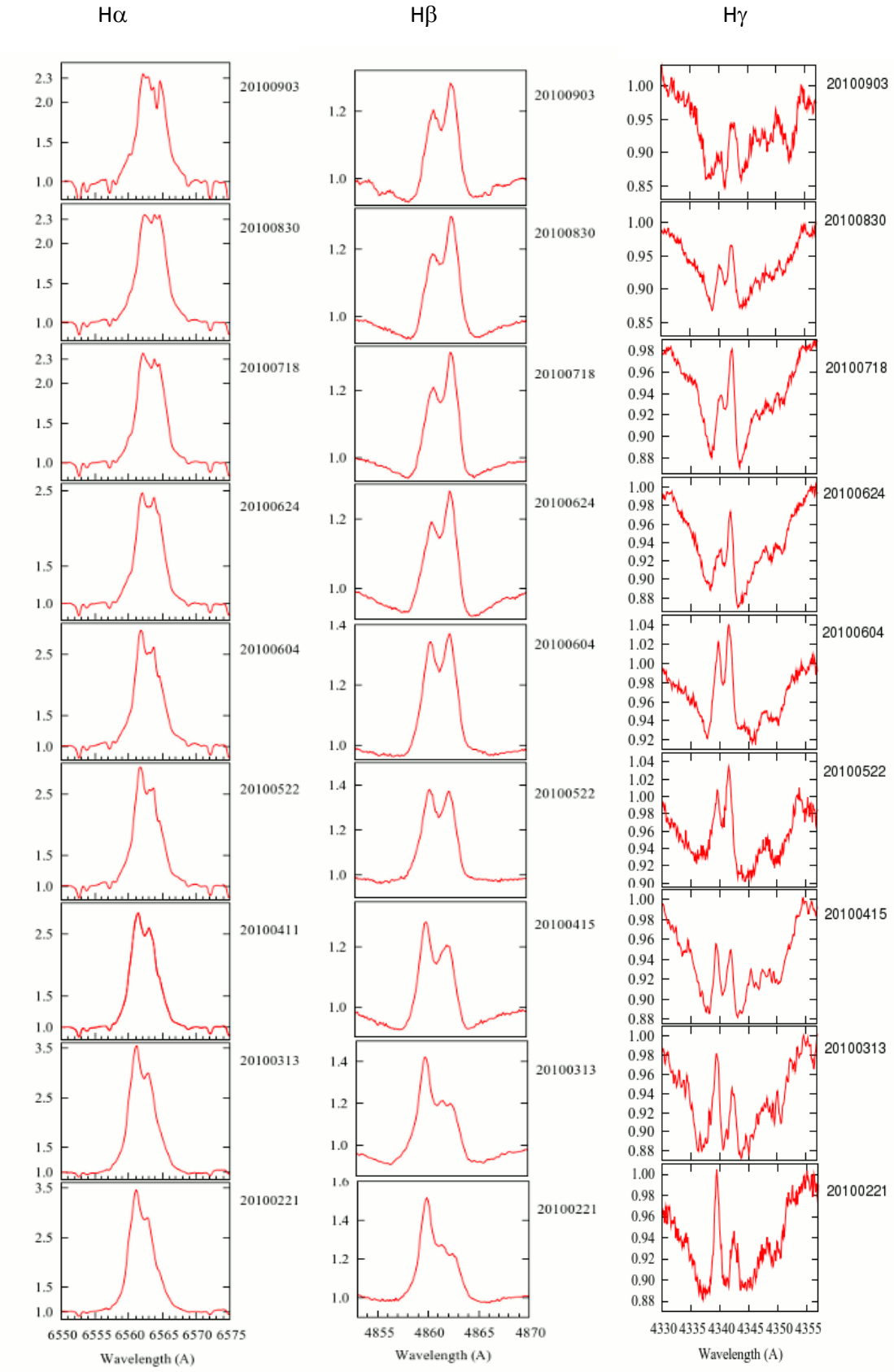

Figure 5.12 – Evolution of H_α, H_β and H_γ lines profile in 2010.