CHAPTER 3

Observation and Data reductions

As discussed in the previous chapter, the observation data was collected by S. Komonjinda at Mt John University Observatory (MJUO) using the 1-m McLellan telescope and HERCULES spectrograph during October 2004 to August 2007. The MJUO is located at latitude 53° 59.2′ S, longitude 170° 27.9′ E, and altitude 1029-meter from the sea-level in New Zealand, time zone +12. EI Eri ($RA = 04^h09^m40^s, DEC = -07°53'34''$) and its neighborhood are shown in figure 3.1

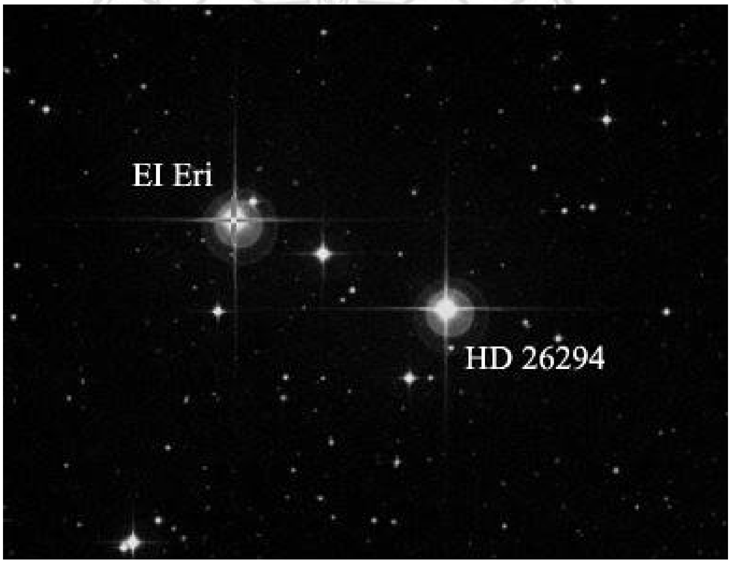

Figure 3.1: The binary system EI Eri and neighbor star HD 26294.

The observational data were recorded by HERCULES spectrograph with a S/N of 100 with 52 images in 31 nights which cover whole orbital phase of the observed binary systems. Each observed spectrum covers wavelength ranges 4657-7060 Angstrom including telluric absorption lines. These spectra were divided into 47 orders with a curved characteristic. This curvature is a result of the spectrograph blaze function. The spectrum can be read like a book starting from the bottom line, in the left (blue part of the spectrum) to right, and then going upward (toward the red part of the spectrum).

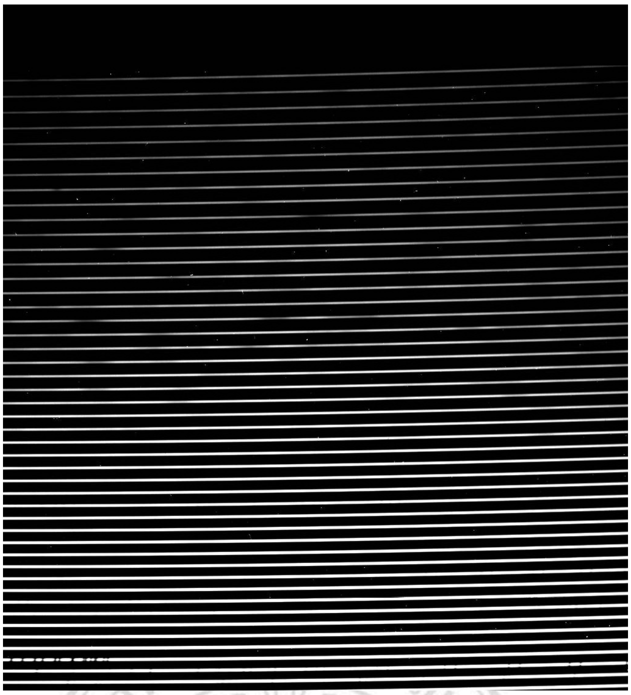

Figure 3.2: Sample spectrum from HERCULES spectrograph.

All archived HERCULES spectra were reduced, by S. Komonjinda (2008), using the *HERCULES Reduction Software Package* (HRSP) version 2.2 (*Skuljan*, 2003). For each observed spectrum, the reduction process was done by using white lamp and Th-Ar spectra to extract order from stellar spectra including correction of the continuum curvature and normalization of the continuum level. Barycentric radial velocity correction and Julian date correction is computed automatically from the middle exposure time by HRSP. HRSP uses its own table of the position and velocities of the Earth which is precomputed using the DE200/LE200 ephemerides by the Jet Propulsion Laboratory (JPL). The final reduction step is to rebin a spectrum from pixel space to wavelength space.

According to figure 3.3, the example observed spectrum in 4720-5020 Angstrom (order 7-13) was observed and reduced automatically by HRSP was shown. It can be noticed that, there is a zero-level gap between each order and a little overlapping. These are due to the CCD detector is not cover the whole spectra. For the instrument characteristic, an echelle spectrograph is a cross-dispersed spectrograph. A first dispersion is made by echelle grating and the second disperser from prism. This allow spectra order to combine high resolution and also have a little bit overlap between orders, then the order spectra are

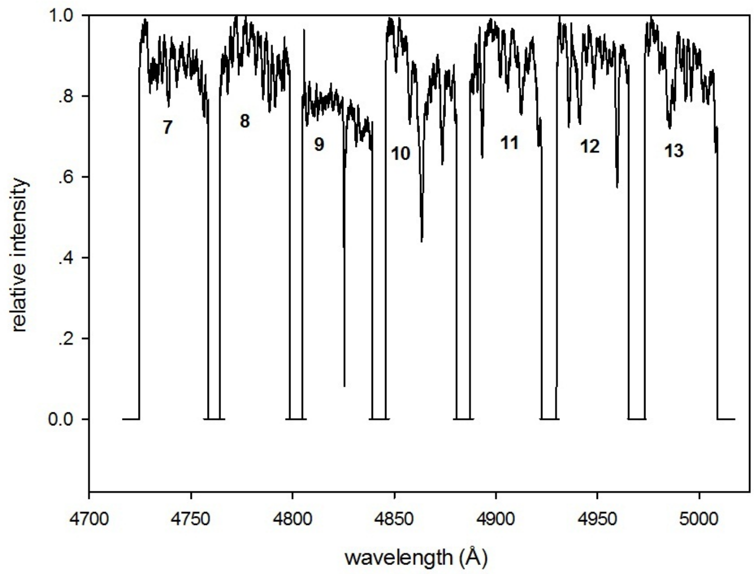

Figure 3.3: Example spectrum of EI Eri from 11/12/04 shows the different level continuum and gap between orders.

also appeared overlapping each other.

The second unusual was, a continuum level distortion which may cause during the data reduction. As two mistake of the data reduction, the zero-level gap can be ignored to determine velocity reduction, because of the velocity analysis is to measure the variation of position of line shifted and line broadening which every spectral lines should be shifted and broadened almost same value, it was not essentially corrected. But for the continuum level distortion, these must be reconstructed continuum level become one as we need to know absolute intensity of spectral line without any factor.

To rebuild normalize observed spectrum, Vienna Atomic Line Database (VALD; *Kupka et al.* 1999)[9] is used for convenient and accurated reduction. VALD is one of the technique's fundamental assumptions requires hydrogen and helium as well as the metal lines exhibiting strong, to prepare the synthetic spectrum in accordance with its fundamental parameter in a particular wavelength ranges. VALD was calculated in atmospheric conditions in fundamental parameters taken into account formulated by *Tkachenko et al.* 2013[17]. We assume T_{eff} = 5700K, log_g = 4.0, $v$sin i = 50km/s, R = 41000 and fix

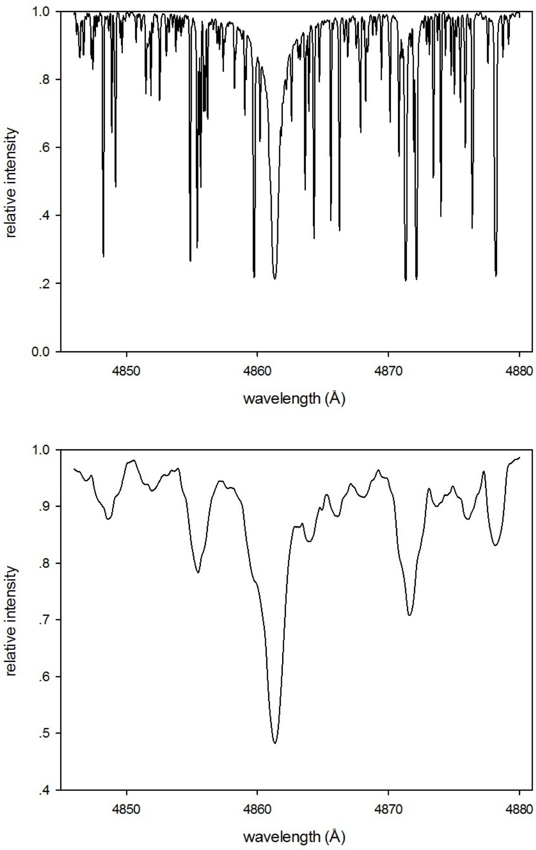

Figure 3.4: The synthetic spectrum of binary system computed assuming fundamental parameter by using VALD showing synthetic spectrum no convolve (upper) and was convolved (bottom) with rotational velocity around 50 km/s in particular wavelength 4837-4888 Å.

microturbulent velocity to 2 km/s figure 3.4.

After the preparation of synthetic spectrum, the normalization procedures are applied. It is to divide observed spectrum by shifted synthetic spectrum, which synthetic spectrum were shifted in velocity scale exactly the same position as observed spectrum, to find a fitting polynomial correspondingly. Normalized spectrum was achieved by observed spectrum divided again by polynomial fitting line figure 3.8. According to the procedure, the spectrum line in a particular wavelength was displaced into continuum level, as shows in figure 3.5.

Finally, observed spectrum were reduced in whole order spectra step by step manually.

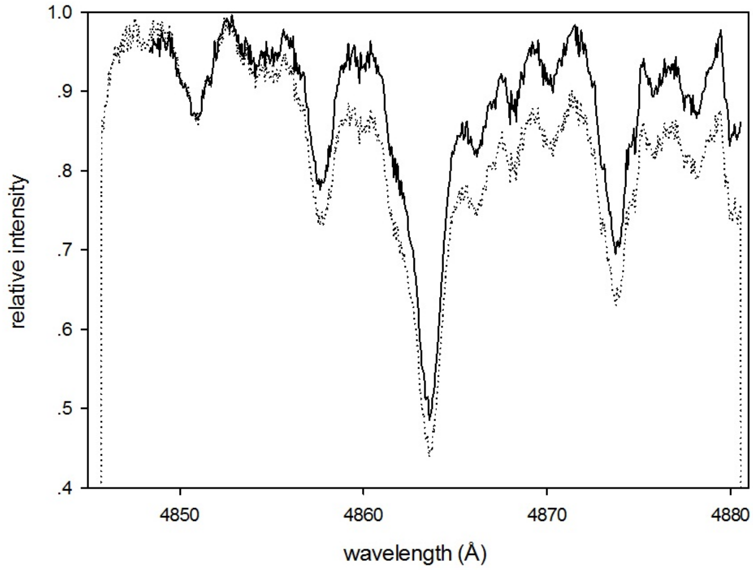

Figure 3.5: The spectrum profiles are compared to show the different observed spectrum before (solid line) and after (dotted line) normalization. We can see that the comtinuum level become better and useful to the LSD technique.

One thing we can see when whole spectrum are compared to each other is that the position of spectra line of each spectrum are different and spectral line are shifted, depends on the radial velocity of the object at that time.

For instance, the spectrum in wavelength range 4848-4880 Å, which has a Balmer series (4861 Å), are compared in different observed time. The position of spectral line is expressing in figure 3.7.

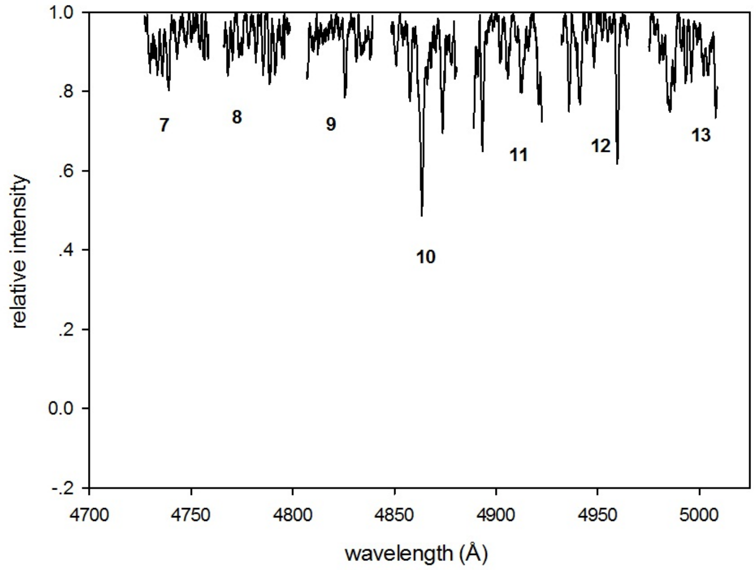

Figure 3.6: The example spectrum in order 7-13 after were reduced.

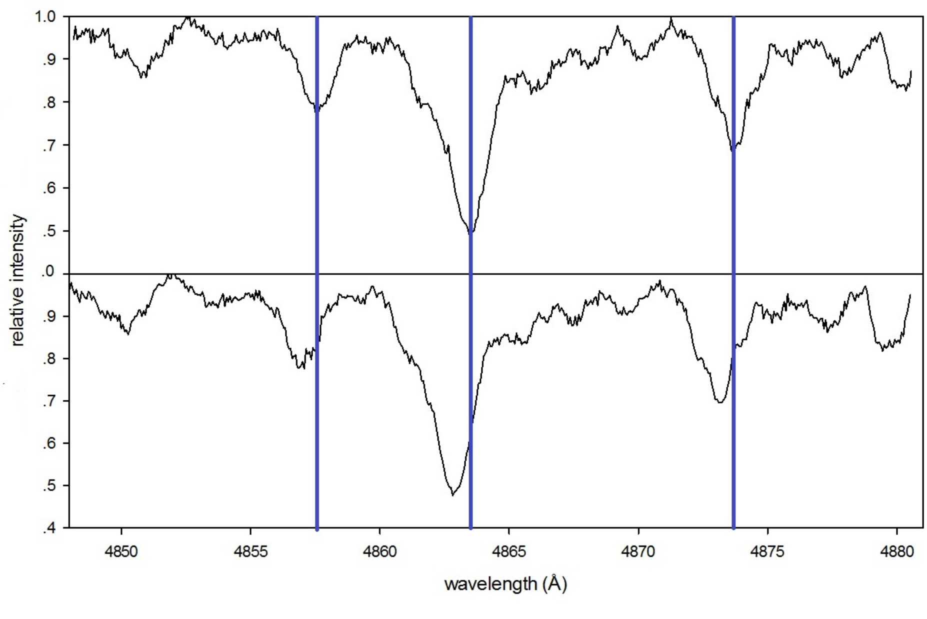

Figure 3.7: Both two spectra in wavelength range 4848-4880 Angstrom are compared each other to see the variation of spectral which both of them are observed at a different time.

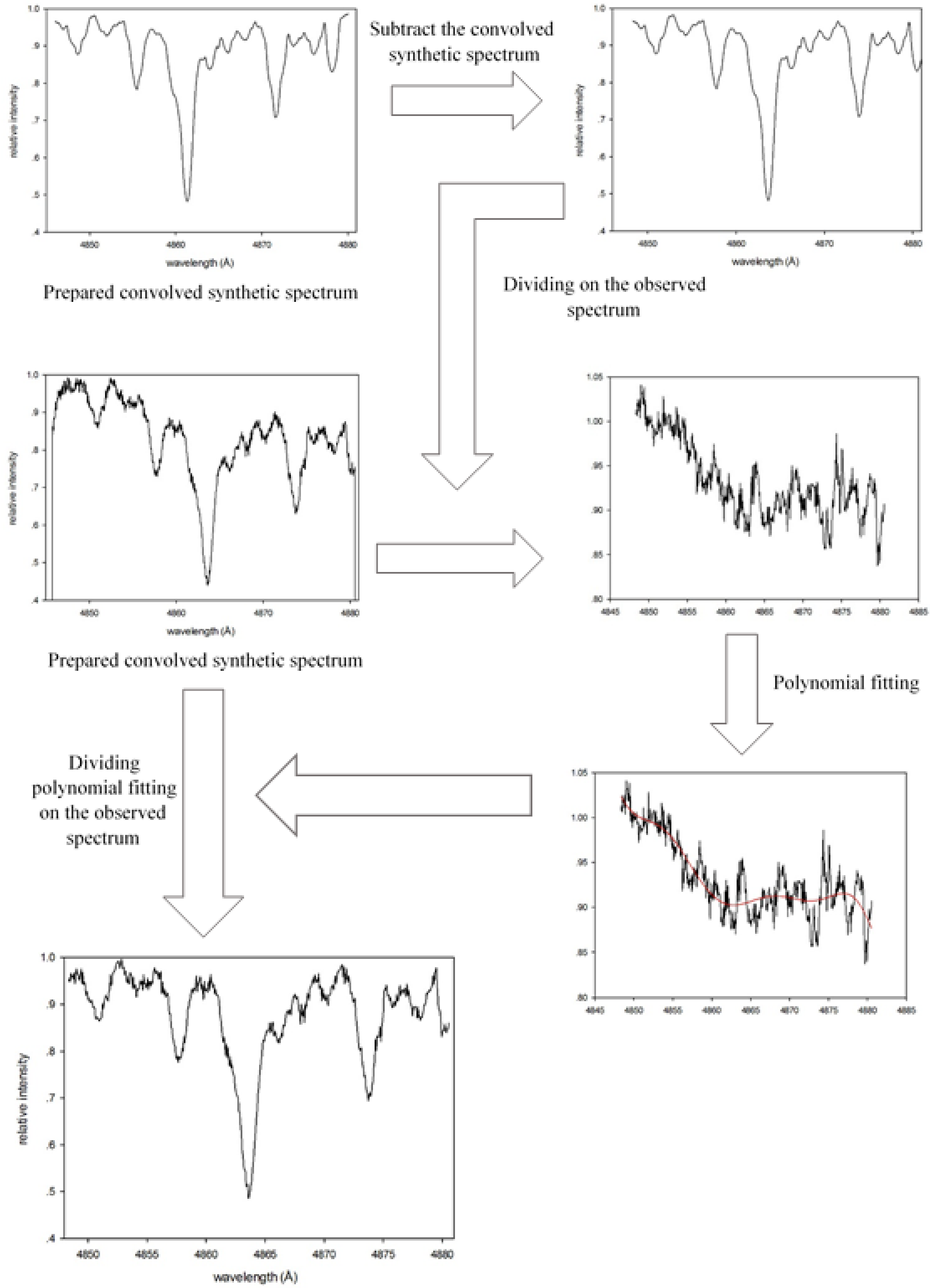

Figure 3.8: The reduction method of HERCULES spectra.