(Form 5)

Forefront Physics and Mathematics Program to Drive Transformation (FoPM)

Report for the International Research Experience

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Figure 1. The photo of the DST telescope.

My previous work is focusing on predicting and analyzing the possible Stokes profile of various chromospheric phenomena. In our previous result, we have already analyzed the Ca II 8542Å Stokes profile of chromospheric reconnections and shocks, and proposed several promising modes of Stokes features which could be used for future analysis in observation. However, our study is almost completely based on theoretical calculations which might be too far from real observations. To acquire better understanding of observation (for myself) and compare our results to observations, I made a contact with Prof. Ueno from Hida Observatory in Kyoto University with the help of Natsume-san from Graduate School of Science in Kyoto University, and received an opportunity to work on the observational data from DST telescope (Figure 1) in Hida Observatory. The DST telescope contains two independent observation modules, one of which could provide high spectral resolution observational data with full Stokes profile, which is suitable for comparing with our result. Due to the limitation on schedule, I have to decline the kind suggestions from Prof. Ueno that submitting my own observational proposal to acquire observational data from DST (i.e. directly do the observation) by myself. Instead, I received massive help from Dr. Anan that providing me with calibrated observational data from previous observation archives.

Figure 2. The photo of the 4th building of Graduate School of Science of Kyoto University.

Although the Hida Observatory is located far from the Kyoto City, the Astronomical Observatory, which the Hida Observatory belongs to, is located in the Graduate School of Science Building in Kyoto University Yoshida campus. During my stay, I worked in the Astronomical Observatory in Kyoto University campus. Figure 2 shows the 4th Building of Graduate School of Science of Kyoto University, in which the Astronomical Observatory is located. The telescope on the top is for educational usage. I got a desk in 4th floor for research purposes, thanks to the help of the local secretary office. Figure 3 shows my working place. The monitor is showing the view and the detail profile of observational data I received.

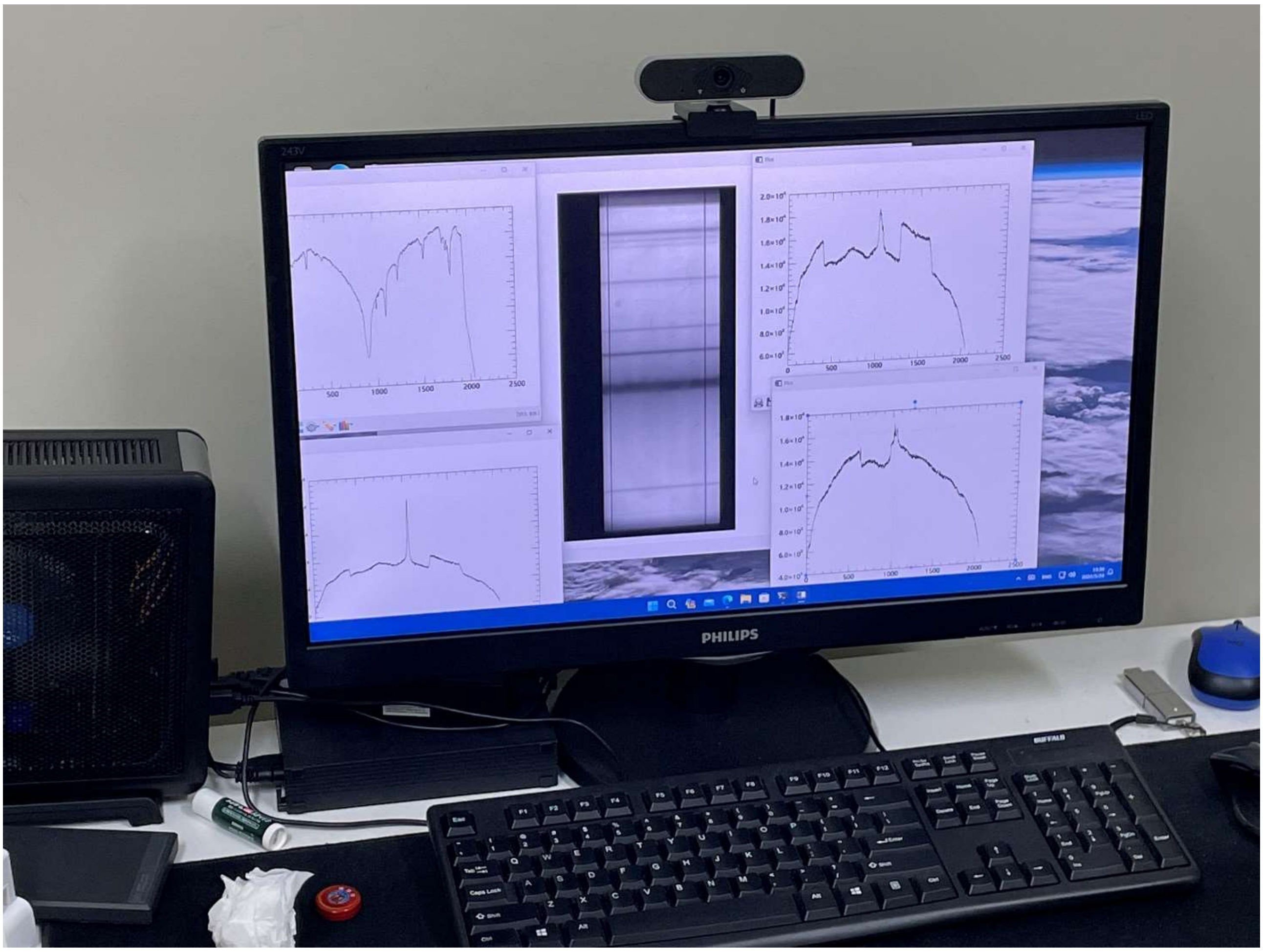

Figure 3. My working place with the viewing of observational data I used in this study.

Prof. Ueno kindly provided many possible data candidates for me. As far as I checked their descriptions, most of them were observing the NOAA active regions, and the observing time were around 1-2 hours. In our previous study, we were focusing on magnetic reconnections and shocks. The occurrence of shocks is much more frequent in the solar atmosphere than that of the magnetic reconnections in our simulation. Also, the spatial structure of shocks is much simpler than magnetic reconnections. Thus I choose to find shocks since it could be much easier to find shocks in observational data rather than reconnections. Another thing needs to be considered is that the assumptions we adapted in our theoretical study, which is the completely vertical observing Line-of-Sight (LOS). Choosing such a LOS could suppress the Hanle effect (a polarization effect which could alter the Stokes profile) that we did not take into consideration in our theoretical study. I picked up 4 candidates with LOS close to our assumptions among 16 choices and lucky received one observing the disk center (which means LOS is almost vertical).

As for the content of observational data, many aspects are quite different from our theoretical study. The first problem was about the wavelength. The data I received does not contain the information of absolute wavelength of each spectral slit (Although the spectral resolution is known). I have to locate the central wavelength by my self (absolute wavelength table is provided with synthesis result in our previous theoretical study). In a typical Stokes I profile (e.g. the upper left profile in Figure 3), the deepest absorption would appear around the central wavelength, which could indicate the absolute wavelength. On the other hand, in some cases peculiar shape of profiles (e.g., profiles in Figure 3 except the upper left one) might appear, in which the wavelength of the deepest absorption may not indicate the central wavelength. Thus, I made a histogram of the location of the deepest absorption. Most of these locations are concentrated around some position, as I expected, but there are also some points far from the concentrated position. By neglecting these unusual (occurrence count less than half of the largest count) points, I obtained the central position as the mean position of the rest part. The uncertainty of this central position is about 5 slits, which leads to Doppler velocity of about 1km/s. This quality is good for a starting point, still I will check more material about this part for a better quality.

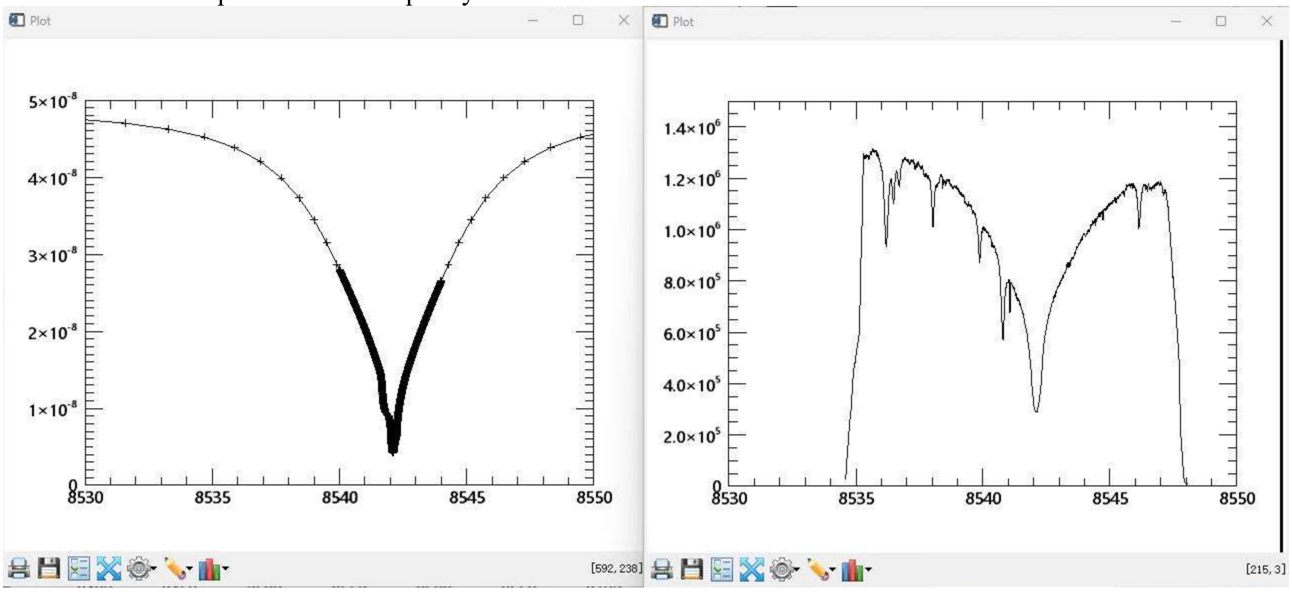

Figure 4. Comparison between the raw data of synthetic profile (left) and observational profile (right) around 8542 Å.

With the position of the central wavelength (8542 Å), the general view of observational profiles could be compared to our theoretical study. However, the behavior and the data form are highly different. Figure 4 shows both the theoretical profile (left) and the observational profile (right). In the theoretical case, the signals are captured over the whole range (from several hundreds Å to 10,000 Å) and 1mÅ spectral resolution is adapted from 8540.5 Å to 8543.5 Å. In the observational case, the data is uniformly captured in a limited wavelength range (~8535 Å to ~8548 Å). The first problem of this is about the so-called continuum intensity (I_c). Basically, the intensity outside of any absorption such as 8542 Å is nearly constant (which is defined as the continuum intensity), this value is generally used to 'normalize' the Stokes IQUV signal (e.g., use I/I_c or V/I_c instead of raw data). In theoretical work, I could simply use the signal outside of the absorption, but in this observational case, the continuum intensity is not captured in the limited wavelength range. I have to use the top 10% signal (which could handle both typical profile and peculiar profile appropriately) instead of continuum intensity (this might indicate the reason why Stokes I amplitude in our theoretical profile is weaker than previous observations)

After these processing, I checked these observational profiles. I found several profiles show similar features as our theoretical results of shocks. Unfortunately up to now the amplitude of Stokes Q/U/V of analyzed data was too weak to show any recognizable features compared to our theoretical results. Further knowledge and investigation might be required. As I have received the permission to use these data by myself in the future, I will continue to analyze the remaining data afterwards.