First Asia-Pacific Solar Physics Meeting
ASI Conference Series, 2011, Vol. 2, pp 405–409
Edited by Arnab Rai Choudhuri & Dipankar Banerjee

Ulugh Beg Astronomical Institute of Uzbek Academy of Sciences – history and current status of solar physics research

Sh. Ehgamberdiev[1*] and A. Serebryanskiy[1]
[1] *UBAI, 100052, Astronomicheskaya-33, Tashkent, Uzbekistan*

Abstract. We outline the history of solar physics research which has been conducted in Ulugh Beg Astronomical Institute of Uzbek Academy of Sciences for more than 120 years. We also highlight the most prominent achievements of our team in the past 20 years, especially using helioseismic methods.

Keywords : Sun: activity – Sun: general – Sun: helioseismology

1. Introduction

In the history of Tashkent Astronomical Observatory (TAO, since 1873), organized later in 1966 as the Astronomical Institute, solar physics research was always one of the major activities. During more than 100 years, scientific research in the institute was concentrated on different aspects of solar physics, including almost continuous monitoring of sunspots and other features of solar atmosphere. In the past 20 years, solar physics research in the institute has been mainly concentrated in the field of global and local helioseismology where we were able to achieve many interesting and important results.

2. History of Solar Physics Research in UBAI

Solar observations started at TAO in 1884 with the help of the Merz 6-inch refractor telescope and observational data were sent to Zurich (Slonim & Korobova 1974;

*email: shuhrat@astrin.uz

Slonim 1974). In 1932 the Soviet Solar Watch was organized with headquarters located at the Pulkovo observatory. At the beginning it consisted of only three stations, Pulkovo, Kharkov observatories and TAO. Since then, solar observations have been carried out at TAO in a regular way. In the autumn of 1932 TAO was equipped with a Zeiss solar spectroscope provided by Pulkovo. Since then regular observations of prominences in the hydrogen $H\alpha$-line have been carried out as well. The spectroscope was attached to the Merz refractor and provided with a micrometer which allowed the height of prominences to be measured. These visual observations continued until 1952.

Since 1936 TAO has taken part in the International Flare Patrol, organized on G.E. Hale's initiative. Visual observations were carried out with the Zeiss spectroscope and since 1957 with the Hale-type spectrohelioscope. In 1958 a new chromospheric telescope with $H\alpha$-filter was installed, which allowed to perform cinematographic survey of the chromosphere and flares.

The next important step in the development of observational facilities at TAO was the installation of the horizontal solar telescope AZU-5 in 1967. The AZU-5 was equipped with a spectrograph with a grating, which allowed operation in the second order with a dispersion of about 1 Å/mm.

A new era in solar research at TAO started in 1987 when a spectrophotometer of the helioseismological IRIS (International Research on the Interior of the Sun) project, with headquarters at the University of Nice (France), was installed at Kumbel mountain, located at 75 km north-east of Tashkent (Egamberdiev & Fossat 1991; Baijumanov et al. 1991). The IRIS project, which consists of six identical instruments installed around the Earth, aimed to obtain an uninterrupted, long duration time series of global solar oscillations of the Sun. The Kumbel station of the IRIS network appeared to be one of the best and provided the IRIS data bank with about 40% of its observational data. Along with other members of the IRIS project, Uzbek astronomers have contributed to obtaining important scientific results. These include measurements of the p-mode amplitude modulation rate (related to the excitation and damping of the solar acoustic oscillations) (Egamberdiev et al. 1992)), the determination of the solar atmospheric acoustic cutoff frequency (Fossat et al. 1992), and studies of the acoustic flux propagating upwards to the chromosphere, which could explain the temperature rise in this upper part of the solar atmosphere. And the most important result obtained with the IRIS network is the measurement of the solar core rotation rate up to 0.2 solar radii (Gizon et al. 1997). On the basis of analyses of about 10,000 hours of nearly continuous time series of solar global oscillations, it was shown that the solar core is rotating as fast as the envelope. This experimental result was in contradiction with the previously existing opinion that the core rotated at least ten times faster than solar surface (Lazrek et al. 1996).

In the summer of 1996, UBAI became involved in the Taiwan Oscillation Network (TON) project. The TON is a global ground network, dedicated to study the solar interiors with high-spatial-resolution and high-duty-cycle K-line data (Chou et al. 1995). It consists of four identical telescopes at appropriate longitudes around the globe. One of the TON telescopes was installed in Tashkent in 1996. The TON data can provide information of solar p-modes up to $\ell = 1000$. With this wide range of mode degree, the TON data can be used to study the local properties as well as the global properties of the solar interiors. In particular, the data taken with the TON telescope in Tashkent together with the data taken at other TON telescopes were used to construct three-dimensional intensity and phase maps of the solar interior with a newly developed method, acoustic imaging (Chang et al. 1997; Chen et al. 1997, 1998; Chou et al. 1999; Chou 2000). Another example of the important studies using the TON data taken in Tashkent is the solar-cycle variations of meridional flows: discovering the new divergent component of meridional flows associated with solar activities (Chou & Dai 2001; Chou & Ladenkov 2005).

Today, together with traditional TAO solar investigations, new fields of research, such as X-ray bright point sources (Egamberdiev 1983; Sattarov et al. 2005a,b) and earthshine monitoring for the study of global warming mechanisms (Chou et al. 2006, 2010) are being carried out.

3. Local helioseismology study and results

In this section, we briefly discuss some of our major studies and results on local helioseismology.

3.1 Life-Time of High-degree Solar p-modes

The lifetime of high-ℓ mode is difficult to measure with the conventional method, the width of mode line profile, because of mode blending. We are the first to use the time-distance technique to measure the lifetime of the wave packet of high ℓ (Chou et al. 2001; Chou & Ladenkov 2007; Burtseva et al. 2007).

3.2 Searching for Magnetic Fields near the Base of the Solar Convection Zone

The dynamo is the central issue in solar physics. It is generally believed that solar magnetic fields are generated near the base of the convection zone (BCZ). The detection of the solar-cycle variations of physical parameters near the BCZ could serve as an evidence of existence of magnetic fields near the BCZ. We apply the time-distance technique to measure the solar-cycle variations of the travel time around the Sun for particular p-modes to show the signature of magnetic fields near the BCZ (Chou & Serebryanskiy 2002; Chou, Serebryanskiy & Sun 2003). We also use the solar-cycle variations of p-mode frequencies, normalized by mode mass, as a function of phase speed to infer a strength of $1.7 - 2.9 \times 10^5 G$ for magnetic fields near the BCZ (Chou & Serebryanskiy 2005; Serebryanskiy & Chou 2005). These results were cited as one of the most interesting astrophysical results in 2005 and 2006 (Trimble, Aschwanden & Hansen 2006, 2007).

3.3 Meridional Circulation Study With Time-Distance Analysis

Using the TON data from 1994 to 2003, we have found that the additional divergent meridional flows deep in the solar convection zone correlate with magnetic fields of 11-year cycle. This divergent flow extends down to 0.8 of solar radius and peaks at a depth of 0.9 solar radius. Its amplitude correlates with the sunspot number (Chou & Ladenkov 2005). This phenomenon is confirmed by other authors and our recent study (Serebryanskiy et al. 2011). Our recent study using GONG++ data shows the meridional flow speed increasing with depth, although the flow absolute speed may be suffered from systematic effects. This work was made in close collaboration between UBAI, Astrophysical Laboratory of Tsing Hua University (Hsinchu, Taiwan), National Solar Observatory (Tucson, AZ) and NMSU (Las Cruces, NM).

Acknowledgments

We would like to express our sincere appreciation to Prof. Arnab Choudhuri for his warm invitation to present our paper in this proceedings.

References

Baijumanov A., et al., 1991, Solar Phys., 133, 51
Burtseva O., Kholikov S., Serebryanskiy A., Chou D.-Y., 2007, Solar Phys., 241, 17
Chang H.-K., Chou D.-Y., Labonte B., The TON Team, 1997, Natur, 389, 825
Chen H.-R., Chou D.-Y., the TON Team, 1997, ApJ, 490, 452
Chen H.-R., Chou D.-Y., Chang H.-K., Sun M.-T., Yeh S.-J., LaBonte B., the TON Team, 1998, ApJ, 501, L139
Chou D.-Y., et al., 1995, Solar Phys., 160, 237
Chou D.-Y., Chang H.-K., Sun M.-T., LaBonte B., Chen H.-R., Yeh S.-J. & the TON Team, 1999, ApJ, 514, 979
Chou D.-Y., Solar Phys., 192, 241
Chou D.-Y., Dai D.-C., 2001, ApJ, 559, L175
Chou D.-Y., Ladenkov O., 2005, ApJ, 630, 1206
Chou D.-Y., Ladenkov O., 2007, Solar Phys., 241, 7
Chou D.-Y., Serebryanskiy A., Ye Y.-J., Dai D.-C., Khalikov S., 2001, ApJ, 554, L229
Chou D.-Y., Serebryanskiy A., 2002, ApJ, 578, L157
Chou D.-Y., Serebryanskiy A., 2005, ApJ, 624, 420
Chou D.-Y., Serebryanskiy A., Sun M.-T., 2003, Space Science Review, 107, 35

Chou D.-Y., Sun, M.-T., Yang M.-H., 2006, Space Science Review, 122, 221
Chou D.-Y., Sun M.-T., Fernandez Fernandez J., Wang L.-H., Jimenez A., Serebryanskiy A., Ehgamberdiev S., 2010, AdAst, 2010
Egamberdiev S. A., 1983, SvAL, 9, 385
Egamberdiev S., Fossat E., 1991, Solar Phys., 133
Egamberdiev S., Khalikov S., Lazrek M., Fossat E., 1992, A&A, 253, 252
Fossat E., et al., 1992, A&A, 266, 532
Gizon L., et al., 1997, A&A, 317, L71
Lazrek M., et al., 1996, Solar Phys., 166, 1
Sattarov I., Pevtsov A. A., Karachik N. V., Sattarova B. J., 2005a, ASPC, 346, 395
Sattarov I., Pevtsov A. A., Karachik N. V., Sattarova B. J., 2005b, ASPC, 346, 363
Serebryanskiy A., et al., 2001, NewA, 6, 189
Serebryanskiy A., Chou D.-Y., 2005, ApJ, 633, 1187
Serebryanskiy A., Kholikov S., Hill F., Jackiewicz J., 2011, SPD, 1614
Slonim Y. M., Korobova Z. B., 1974, AZh, 51, 1258
Slonim Y. M., 1974, aiu..conf, 88
Trimble V., Aschwanden M. J., Hansen C. J., 2006, PASP, 118, 947
Trimble V., Aschwanden M. J., Hansen C. J., 2007, SSRv, 132, 1