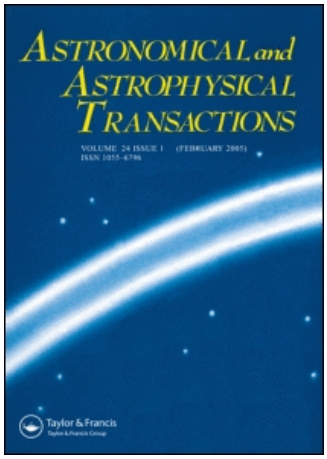

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CHARGE-COUPLED DEVICE OBSERVATIONS OF THE OPEN CLUSTER NGC 6823 AND ASSOCIATED BRIGHT NEBULA NGC 6820: FIRST RESULTS AND PROSPECTS OF THE UZBEK–TAIWAN COLLABORATION AT MAIDANAK

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Preliminary results of broad-band and narrow-band charge-coupled device imaging of the young star cluster NGC 6823 and the associated bright nebula NGC 6820 are reported. The observations were made in August 2001 at Maidanak Observatory (Uzbekistan) as a collaborative initiative between the Graduate Institute of Astronomy, National Central University, Taiwan, and Ulugh Beg Astronomical Institute, Uzbek Academy of Sciences. The two institutes, together with colleagues from Lithuania and Latvia, are working together to modernize and instrument the existing telescope facilities at Maidanak to make use of the excellent astroclimate of the site. As a pilot project, we selected candidate young stars in NGC 6823, based on their 2MASS near-infrared colours and obtained their photometry with Maidanak telescopes. The youth natures of some of these sources were later confirmed by spectra taken by the 2.16 m telescope at Beijing Observatory. This demonstrates that combination of small telescopes and existing databases, such as 2MASS, ROSAT or Chandra, can yield fruitful science. Other Uzbek–Taiwan collaborations are being planned.

Keywords: Young stars; Open clusters; International collaboration

1 INTRODUCTION

At present the only effective way to advance science in Uzbekistan, which has a long tradition in astronomy, is through mutually beneficial international cooperation fostering the financial and intellectual resources of different countries. This will help Uzbek astronomers to continue their research and at the same time will provide the international community with telescope access to the facilities installed at Maidanak in Uzbekistan.

Known among the FSU astronomical community, Mt Maidanak was said to be the best site for an astronomical observatory among about a few dozen tested in the early 1960s. The reason was that within the FSU sovereignty the southern–western part of Central Asia was found

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to have the maximum number of clear nights, the highest atmospheric stability and the lowest water vapour content in the air. Maidanak (66°56′ E; 386°41″ N; H = 2600 m) is an isolated summit in part of the Pamir and Alay mountain range. A long-term astroclimatic exploration starting in 1969 indicated that Maidanak had excellent observing conditions, typically at sub-arcsecond levels, a sufficient number of clear nights, a dark night sky and good atmospheric transparency. It thus competes as one of the most preferable sites worldwide for ground-based astronomy. Latest tests with an ESO Differential Image Motion Monitor (also used for site testing in Chile) and a generalized observation monitor confirmed the previous conclusions (see, for example, Ehgamberdiev et al. (2000) or visit URL http://www.eso.org/gen-fac/pubs/astclim/espas/maidanak/).

The Maidanak Observatory has about ten telescopes, including a 1.5 m telescope, a 1.0 m telescope and others with aperture sizes of 0.6 m or less. These telescopes, if appropriately equipped, together with the astroclimatic and longitudinal advantages of the site, will make Maidanak Observatory very competitive for astrophysical research, especially in high-angular-resolution imaging, and long-term monitoring programmes via global telescope networking. The National Central University (NCU), Taiwan, actively developing its own small-telescope facility, has taken the opportunity to team up with the Ulugh Beg Astronomical Institute (UBAI), Uzbekistan. Below we present the preliminary results of our study of the star cluster NGC 6823 and the associated bright H II region NGC 6820.

2 THE OBSERVATIONS AND PRELIMINARY RESULTS

Candidate young stars (T Tauri stars and Herbig Ae–Be stars), have been selected based on their 2MASS near-infrared colours (Lee and Chen, 2002), in the general region in NGC 6820 and NGC 6823 (Fig. 1).

A total of 20 Herbig Ae and Be and 40 T Tauri candidates have been identified. Imaging observations were carried out at Maidanak Observatory in August 2001. Of the ten nights of our observing run, eight were perfectly clear and one was partially cloudy before a rainy day. The viewing conditions were remarkable, sometimes as good as 0.3″, with 0.6″ average.

We used the 1.5 m and one of the 0.6 m telescopes. The Zeiss 0.6 m telescope was used for photometry imaging. A high-sensitivity (QE about 90%) water-cooled charge-coupled device (CCD) AP-8e camera, with an SITe SI-003AB 1024 × 1024 CCD (Apogee Technology Inc.), was used, with UBVRI, Hα (656.3 nm; passband, 30 nm), [O III] (500.7 nm; passband, 30 nm)

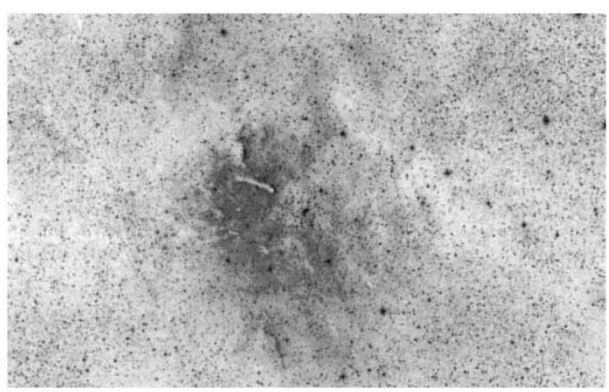

FIGURE 1 The DSS red image of NGC 6820 and NGC 6823.

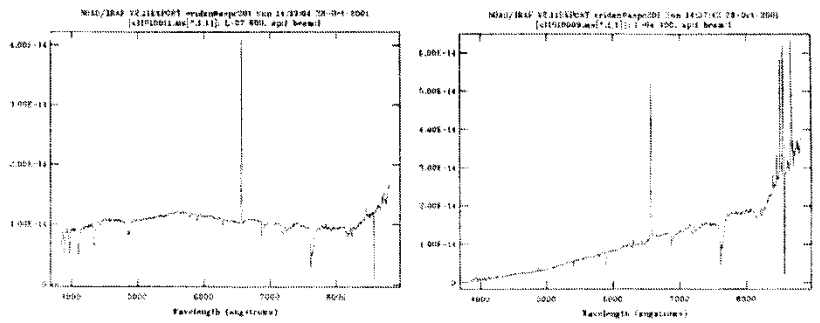

FIGURE 2 The low-resolution spectra of (a) an early-type and (b) a late-type young star.

TABLE I New Young Stars Found in NGC 6820 and NGC 6823.

Number	Right ascension (2000) (h min s)	Declination (2000) (h min s)	Type	J	H	K_s
1	19 42 27.92	+23 05 14.7	CTTS	11.047	10.275	09.689
2	19 42 54.99	+23 24 14.8	CTTS	10.343	09.333	08.404
3	19 42 57.68	+23 22 52.1	CTTS	12.955	12.213	11.622
4	19 43 04.40	+23 18 48.7	HAeBe	11.579	10.515	09.601
5	19 43 07.51	+23 26 02.9	HAeBe	12.753	11.811	10.970
6	19 43 08.59	+23 25 45.7	HAeBe	13.595	12.784	12.066
7	19 43 10.17	+23 25 31.1	HAeBe	13.558	12.304	11.381
8	19 43 20.99	+23 19 02.3	HAeBe	13.057	11.557	10.355

and [S II] (672.4 nm doublet; passband, 50 nm) filters. For the NGC 6823 observations, R and I filters were used. The entire NGC 6820 and NGC 6823 region was surveyed by mosaicing.

The 1.5 m AZT-22 telescope (LOMO, Russia), with nearly diffraction-limited optics and careful thermostabilization, allows high-angular-resolution imaging. It is equipped with a professional liquid-nitrogen-cooled CCD-camera, with an SITe-005 2000×800 CCD (Copenhagen University Observatory, Denmark), provided by the Maidanak Foundation and equipped with standard Johnson UBVRI as well as narrow-band Hα (656.3 nm; passband 30 nm) filters. For our NGC 6823 observations, the 1.5 m telescope was used in Hα for small regions that called for careful examination of the images taken by the 0.6 m telescope.

Some of the young star candidates were observed in October 2001 and again in February 2002 with the spectrometer on the 2.16 m telescope of Beijing Observatory in China. Both low-dispersion (200 Å mm^{-1}, 1.2 Å $pixel^{-1}$ and 2.5′ slit) and higher-dispersion (50 Å mm^{-1}) spectra were obtained. Eight sources have been found to show Hα emission in their spectra, of which five are probable Herbig Ae–Be stars (HAeBe), and three are probable classic T Tauri stars (CTTSs). Figure 2(a) and (b) show typical low-resolution spectra of an early-type and a late-type young star, respectively, thus identified. These young star candidates, and their 2MASS magnitudes, are summarized in Table I.

3 CURRENT AND FURTHER PLANS OF COLLABORATION

The collaboration between the NCU and the UBAI was initiated in January 2001 during an IAU colloquium on small-telescope astronomy held in Kenting, Taiwan. In the subsequent summer a Taiwanese team visited the UBAI in Tashkent and observed at the Maidanak

Observatory jointly with colleagues from Uzbekistan. The visit to Maidanak concluded with the impression of the good sky conditions and the lack of proper instrumentation at the site. An immediate solution would be to renovate the existing facilities.

A Memorandum on Scientific and Technical Collaboration was signed in early 2002 between the two institutions. Our collaboration now has extended to include Latvian, Lithuanian and Chinese astronomers, initially for open-cluster research and later to include variable-star studies. Recently the NCU team installed a 1 m telescope at Lulin Observatory in Taiwan. It will become part of a consortium to include other small telescopes (e.g., Maidanak and Yunnan) for global time variability monitoring, or for complementary observations (e.g., the Moletai 1.65 m or the Beijing 2 m for spectroscopy). In the future this network will expand to take part in global variability monitoring campaigns, for example for asteroseismology, search of extra-solar planets or monitoring X-ray binaries, etc. Our pilot project on NGC 6820 and NGC 6823 demonstrates the effectiveness of combining databases (2MASS, ROSAT and Chandra) and small-telescope observations (imaging photometry and spectroscopy) for a comprehensive study of a targeted star-forming region. A 2 year grant has recently been awarded, under the Taiwan–Baltic Foundation, to reinforce the scientific interaction between these institutions. We foresee scholar and student exchanges, joint workshop conferences, instrumentation development and other research ventures.

Our first endeavour, together with colleagues in Lithuania (Institute of Theoretical Physics and Astronomy, Lithuania, and Vilnius University) and Latvia (IAPS and University of Latvia), is to bring the Maidanak 1 m up to modern standards. An upgrade plan includes the following items:

(i) computer control of the pointing and tracking, with sky chart (Sky–GSC–DSS) interface, and with display and analysis for all telescope status indicators (the user can click on a particular object on a chart and the telescope will slew to it; autoguiding will be available for long exposures);
(ii) computer control focusing;
(iii) synchronized dome (the slit of the dome automatically follows where the telescope is pointing, possibly with an innovative ultrasonic sensor);
(iv) realization of an enlarged field of view with corrector optics in conformance to the future CCD camera;
(v) mirror-cleaning apparatus;
(vi) a new state-of-the-art professional CCD camera;
(vii) a suite of filters (broad and narrow bands).

Part of the upgrade engineering, scheduled to begin in the fall of 2002, will be made by a Chinese group who have successfully upgraded an identical telescope at Yunnan Observatory, China. Instrumentation development will be our next major step, especially infrared cameras for imaging and low-resolution spectroscopy, for which new partners are very encouraged.

4 CONCLUSIONS

This paper presents the initial scientific and technical efforts of a collaboration between Uzbekistan, Taiwan and Baltic astronomers, to make use of the facilities at Maidanak Observatory. CCD observations of NGC 6820 and NGC 6823 carried out at Maidanak, together with data of 2MASS, ROSAT and Chandra databases, allowed us to identify candidate young stars, whose youth nature has been confirmed by spectroscopy performed with the

Beijing 2.16 m telescope. This clearly demonstrates that the combination of small telescopes and existing databases can yield fruitful science. We are taking the first step to bring the Maidanak 1 m telescope up to modern standards, as part of our effort of a consortium of Uzbek, Taiwanese and Baltic astronomers for long-term scientific and technical collaboration.

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