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Small/automated telescopes and backend instrumentation for teaching purpose

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Abstract. In the past decade, with the inception of IUCAA and other similar efforts from Universities and Institutes, several MSc teaching courses at Universities now offer Astronomy & Astrophysics as a special paper along with a set of laboratory experiments using telescopes and various back-end instruments. This paper highlights the small and/or automated photoelectric telescopes (APTs) that could be made or procured for the purpose of teaching at University level and the experiments that could be carried out with this kind of set up. At IUCAA's instrumentation laboratory, over the past few years, APTs have been fabricated along with the required light weight back-end instrumentations and these are discussed.

Keywords : astronomical photometry, automated telescopes and backend instrumentation

1. Introduction

In the recent years, several university departments and institutions have initiated Astonomy & Astrophysics teaching courses at MSc. level offering it as a special paper (similar to electronics, solid-state physics etc.) along with a set of laboratory / outdoor experiments pertaining to the subject. This paper gives an overview of such Universities / Institutions and lists a possible set of such experiments along with the required set of equipments. Finally, a more advanced set up involving a fabrication of an automated telescope for teaching is also discussed.

2. Universities / institutions teaching astronomy with laboratory course

Following is a list of such universities / institutions which are engaged in this activity :

- IUCAA, Pune
- Osmania University, Hyderabad
- Bangalore University, Bangalore
- Raipur University, Raipur
- Gulbarga University, Gulbarga

- SRTM University, Nanded
- D.D.U. Gorakhpur University, Gorakhpur
- Mahatma Gandhi University, Kottayam
- Guwahati University, Guwahati
- Bhavnagar University, Bhavnagar (*)
- J.E.S. College, Jalan (*)
- Mumbai University, Mumbai (*)
- Assam University, Silchar (*)
- Shivaji University, Kolhapur (*)

(*) indicates that they plan to initiate this course

Given the large demand for such course, the following section provides a typical set of experiments which can be introduced.

3. List of possible MSc A & A experiments

1. To estimate the temperature of an artificial star by photometry.
2. To study the characteristics of a CCD camera.
3. To study the solar limb darkening effect.
4. To polar align an astronomical telescope.
5. To estimate the relative magnitudes of a group of stars by a CCD camera.
6. To study the atmospheric extinction for different colors.
7. Differential photometry of a program star w.r.t a standard star.
8. To study the effective temperature of stars by B-V photometry.
9. To estimate the night sky brightness with a photometer.
10. To estimate the distance to the moon by parallax method.

As an example, the first experiment listed above can be described as follows :

On an optical bench (easily available even at BSc laboratories in a dark room) place a small bulb (a torch bulb or a small halogen bulb) on the stand kept on one end of the optical rail. The bulb should have a steady supply with a voltmeter and potentiometer in series. Also the bulb is to be enclosed in a small housing that has a glass diffuser in front (or few sheets of tracing paper) and a small pin hole. The light coming out of the bulb should be seen only through the pin hole as this acts as the artificial star. On the other end of the optical rail (typically 1.5 meter long) place the photometer. Between these two, place a plano-convex lens of about 50mm dia and 150mm focal length. Arrange the position of the lens such that the pin hole is well focussed on the photodiode of the photometer. This completes the setup required for this experiment. Three or more settings of the lamp intensity can be used to simulate the different temperatures of the artificial star. The B and V magnitudes of the star can be measured by using the respective filters of the photometer and the effective temperature of the artificial star can be estimated from a table provided to the students based on standard tables of (B-V) versus Teff.

3. Equipments required for setting up the experiments

- Telescopes – Celestron 8" or Celestron 9" (or Meade for about US$3000/-) or APT 14" (can be fabricated at IUCAA)
- Microguide eye-piece with illuminated reticle – US$200/-
- Photometer – OPTEC SSP3 US$1200/- (www.optecinc.com), IUCAA Photometer (Approx. Rs. 8000/-, 20 Days) IUCAA Night sky photometer (limited sensitivity, Approx. Rs. 1000/-, 10 days)
- CCD Camera – SBIG ST-4 (US$1000/-), ST-6 (US$3500/-), IUCAA CCD Camera (equivalent of ST-6, Approx. Rs. 30,000/- to 40,000/-, 45 days)
- Fiber-fed Spectrometer – US$2300/- (www.sivo.com)
- PC – 486 or higher version
- Filters – various dia BVRI made at IUCAA (for photometry usage)
- LDR sensor – Rs. 20/- (for solar limb darkening experiment)
- Analogue or Digital multimeter
- Site preparation – Terrace with a nearby lockable room – pipe/pier grouted on the building column (to reduce building vibrations). Moving GI sheet shed or water proof cover for the telescope. The PC, instruments etc can be put on a roll-out table.
- Funding support – DST, ISRO (RESPOND), DAE
- Please note that the cost given for IUCAA made items are the cost of components ONLY which are to be reimbursed to IUCAA and interested persons have to make these themselves with IUCAA's guidance at IUCAA visitor laboratory. Contact : Head, IUCAA Instrumentation Laboratory.

4. Automated Photoelectric Telescopes (APT)

An automated photoelectic telescope (APT) was developed at IUCAA Instrumentation Laboratory for various University groups to take it up as a project for their own usage. Bangalore and Bhavnagar Universities have already built one each at IUCAA. The primary use of such APTs will be photometric observations of variable stars using an IUCAA built photometer and a small commercial CCD camera. The advantages of such a telescope are (a) automation, unattended operation (b) remotely controllable (c) programmable for various types of observing schedules and (d) useful for automated search type observations. The cost of such a telescope is about Rs. 5 Lakhs. More details of this can be seen in Gupta (1996). Future plans include using a single CCD camera based autoguiding and photometry and attaching a commercial fiber-fed spectrometer for obtaining bright star spectra.

It is interesting to note that in the recent years this type of telescopes are widely used for astronomy teaching in the international scene. Following is a short list of some of these APTs and one can see more details in Querci & Querci (2000).

- La Palma (Spain) / Liverpool John Moores University (UK) 200cm Robotic telescope (ROBONET)
- Honolulu, Hawaii, LCC Observatory computer operated telescopes 20-30cm
- UC Sanata Barbara, California, Remotely Operated Telescope 36cm (RAAP)

- ◇ Mt. Wilson Observatory, California, Telescopes in Education (TIE) 60cm, 35cm www access
- ◇ Lawarence Berkeley National Observatory, California, Hands on Universe program
- ◇ Winer Mobile Observatory (WMO), Sonorita, Arizona / Iowa Robotic Telescope Facilities (IRTF) 50cm
- ◇ University of Iowa, Iowa, IRTF 18cm refractor
- ◇ Highland Road Park Observatory / Louisiana State University, Baton Rouge Observatory 50cm
- ◇ University of Wisconsin, Oshkosh / University of Illinois, Urbana-Champaign, wwwaccess, STARDIAL
- ◇ Center of Automated Space Science, NASA Univ. Research Center, Maryland with ground based NASA missions
- ◇ Micro Observatory / Harvard-Smithsonian CfA, New Jersey, 5 APTs on internet also 30cm Robotic Telecope at Canary Islands,. Tenerife
- ◇ Bradford Robotic Telescope Observatory, Oxenhope-moore, 46cms, www gateway also 30cm Robotic Telecope at Canary Islands, Tenerife
- ◇ Oxie, Sweden, Tycho Brahe Observatory, Remote control telescope

5. Conclusions

The aim of this paper was to present the basic requirements for introducing a MSc. teaching laboratory course in Astronomy & Astrophysics. Though several Universities and Institutes have been carrying out this course but the laboratory aspect is generally lacking and idea here was to provide the details of these experiments, equipments required, funding sources etc. Over the past decade IUCAA has developed most of these infrastructures in house and any University group interested in requiring guidance or even fabricating with IUCAA's help is welcome. One has to remember that the interested person/group has to develop the set of equipments mentioned in this paper at IUCAA's Instrumentation laboratory on his own and IUCAA will only provide the guidance/facilities for such a venture as per IUCAA's policy (the cost of the components involved have to be reimbursed to IUCAA). This mode of working gives full training to the concerned group such that they can handle almost all the setting up issues related to the laboratory course at their place without any external help.

References

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Querci, F.R., Querci M., 2000, Astrophysics & Space Sci., 273, 257