Abstract

Massive operational overheads and low efficiency still restrict the applicability of AO on large telescopes for which operational costs per unit time are high. On the other hand, small and medium-sized telescopes are many more in number, and their operational costs are substantially lower. A robust AO system, which operates with minimal overheads and provides good sky coverage, will significantly enhance the scientific capabilities of small and medium-sized telescopes by opening up the possibility of hitherto unavailable observational approaches.

RoboAO is the product of a collaborative effort between Caltech, USA and IUCAA, India which started in mid-2009. An initial version of Robo-AO was made operational on the Palomar 60 inch telescope and subsequently on the Kitt Peak 2m telescope. The second version of Robo-AO called iRobo-AO is constructed at IUCAA for deployment on the 2 meter telescope at IUCAA Girawali Observatory. It is very compact. It is designed with off the shelf components to make it low cost. It is an autonomous laser guided adaptive optics system which enables very low operational overhead for moderate size telescopes.

As in the case of most AO systems iRobo-AO too depends mainly on the functioning of three major facilities.

- *The Laser Guide Star Facility mounted at the side of the telescope. It consists of a 355 nm, 10 Watt pulse laser. Light from the laser is focused at a height of about 10 km with the help of a pair of lenses. There are two fold mirrors which bend the beam to make the projector more compact. One of the fold mirrors is a fast steering mirror (FSM) to counteract any pointing error.*

- *The Cassegrain AO Facility mounted at the Cassegrain focus of the telescope. It primarily consists of three arms: two science arms working in the visible and infra-red (IR) and a wavefront sensing UV arm. It mainly consists of five off-axis parabolic (OAP) mirrors, a deformable mirror (DM), a tip-tilt mirror (TTM), a pair of rotating prisms used as atmospheric dispersion corrector (ADC) and two dichroic filters to split up the light into various bands. Apart from these it also has an Electron Multiplying Charged Couple Device (EMCCD) camera, a fast readout UV sensitive wavefront sensing CCD39 camera and an infra-red camera (IR cam) which is indigenously developed at*

IUCAA. The dimension of the entire Cassegrain box is ≈ 1 m × 1m × 0.2 m.

- *One of the features of Robo-AO is its ability to work both in the visible as well as in the NIR wavelength bands. A near infra-red camera (NIR camera) has been developed at IUCAA, to improve the scientific abilities of iRobo-AO. It will provide high-angular resolution, low noise, wide-angle field of view ($\sim 1'$), and high-sensitivity in the near-infrared regime with unprecedented observing efficiency. It will provide iRobo-AO with an additional channel to do real-time tip-tilt correction while science observation is being done simultaneously.*

The present thesis reports, research works done by the author (in collaboration with other team members). This thesis presents the salient features of the adaptive optics system, its assembly and integration as well as various performance test results. The main objectives of the work are

i) review of the AO systems,
ii) design and development of the Cassegrain AO facility,
iii) development of laser guide star system
iv) design and development of atmospheric dispersion corrector with an adaptive atmospheric condition sensitive driving software module,
v) design and development of near infrared camera and
vi) installation and commissioning of iRobo-AO on the 2m telescope at the IUCAA Girawali Observatory (IGO)

The reported material/results of this thesis are from below publications in different journals/proceedings

1. J. Paul, H. K. Das, A. N. Ramaprakash, et al., *" Design and development of an adaptive optics system in visible and near-infrared for Inter-University Centre for Astronomy and Astrophysics 2-meter telescope"*, J. Astron. Telesc. Instrum. Syst. 5(3), 039002 (2019), doi: 10.1117/1.JATIS.5.3.039002.

2. J. Paul, A. N. Ramaprakash, H. K. Das,et al., *"A Near-Infrared Camera for iRobo-AO on the IUCAA 2m Telescope"*, Journal of Astrophysics and Astronomy, 40:28, August 2019., doi: 10.1007/s12036-019-9595-0.

3. J. Paul, A. N. Ramaprakash, H. K. Das, et al., *"Design and Development of IR Camera"*, in Adaptive Optics Systems VI, D. Schmidt, L. Schreiber, and L. M. Close, Eds., SPIE (2018).

4. J. Paul, H. K. Das, A. N. Ramaprakash, et al., *"Laser Guide Star Facility at IUCAA Girawali Observatory, 2m Telescope, India"*, National Laser Symposium (NLS-27), RRCAT, Indore, 03-06 Dec, 2018, NLS_CP-11.15