

# Indo-Belgian Cooperation in Astrophysics: From inception to further prospects

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- ❖ **Background of Indo-Belgian scientific Cooperation**
- ❖ **Advanced Mechanical and Optical Systems (AMOS), Belgian Company**  
**0.5-m MAST, USO; 3.6-m DOT, 4-m ILMT and 2.5-m PRL .**
- ❖ **BINA contributions started in 2016, a decade after Cooperation started.**
- ❖ **Key science results**
- ❖ **Summary and Conclusions**

- Indo-Belgian Collaboration in S&T signed on Nov 3, 2006 between Belgian Federal Office for Science Policy (BELSPO) and Department of Science & Technology (DST); Jean Surdej, Belgium side; Ram Sagar, Indian side and Mr. Bill Collin & J. P. Chisogne, AMOS germinated idea of Indo-Belgian cooperation during 2004-2005.
- It covers wide range in S&T including Physics and Astrophysics as one Key area; Joint committee (JC) consisting officials and experts from both countries monitors the projects. Prof. T. Ramasamy, then Secretary, DST, Government of India, led the first JC meeting; June 23-28, 2007; followed by regular meetings; 5<sup>th</sup> JC meeting held on 18-01-2021.
- BELSPO contributed 2 M€ in the 3.6 m DOT & participated in the 4-m ILMT.
- For developing and strengthening Indo-Belgian collaborations in the area of Astronomy and Astrophysics, RS visited few Belgian Astronomical Research Institutions during May 11 to 15, 2012 and also participated and delivered a talk in the Belgian National Contact group meeting held in Brussel on May 14, 2012.

# AMOS participation in Indian Astronomy Projects

- The AMOS is specialized in making precision instruments in the field of both ground and space based observational sciences; supplied state of the art instruments to institutions like ISRO; mainly collimators to test space instruments and large thermal-vacuum chambers.
- In the area of Astronomy and Astrophysics, AMOS supplied 0.5-m size MAST (Multi-Application Solar Telescope) to USO in 2014; Indo-Belgian 3.6-m DOT in 2016; the 4-m ILMT (2022) and recently PRL Mount Abu 2.5-m telescope.
- On 27 March 2007, AMOS ([Mr. Bill Collin](#)) was awarded the contract for design, manufacture, integration, testing, supply and installation of a 3.6-m aperture size modern optical telescope at Devasthal. In 2008, the BELSPO contributed 2 million Euros in cash to the 3.6-m DOT Project. In return, Belgians get 7 % observing time. It was successfully installed during 2014 to 2015 and technically activated on March 30, 2016 jointly by the Premiers of both countries, India and Belgium from Brussels, Belgium.
- AMOS participated in the 4-m ILMT, another Belgian initiative lead by [Prof. J Surdej from the ULiege](#). This project is in collaboration with ARIES in India and others in Canada. AMOS manufactured the bowl and the mechanical structure of the telescope. Some tests of the liquid mirror concept were also performed in the AMOS factory. Successfully installed in 2022 and inaugurated on March 21, 2023.

# Why AMOS, Belgium was preferred?

- Indo-Belgian cooperation as reflected by the statement “... *this project (3.6-m DOT) has been supported by the Belgian Government and that AMOS as a Belgian company is very much willing that this project becomes a success for both parties*”; AMOS letter (AMOS/ADM/18/439 dated 29 August 2014) written to the ARIES.
- Economical and ease of doing business. For transporting massive and large size parts of the telescope mechanical parts, hilly roads and bridges were inspected by experts from AMOS. Their inputs were implemented particularly in Bhawali town and in Devasthal.



- The 3.6-m **DOT** was to be installed in a limited space; Computer simulations of entire installation process. **Very compact building and optimized use of space.**
- AMOS played very constructive role in replacing Astrositall M1 blank with the Schott, Zerodure. **Coordinated well with both Schott and LZOS companies.**



**Revised agreement signed on 21 August 2008 and AMOS Factory test**

# 3.6 meter DOT

Kumar et al. (2018) **installation, infrastructure development, Telescope building, Mirror aluminum coating plant and first light performance Results; low thermal mass not degrading seeing**  
Omar et al. (2017); Sagar et al (2019, 2020)  
Advantage and performance;



# Observing with 3.6 DOT

<http://www.aries.res.in/dot>

Online User manual provide information

**Belgium 7%; ARIES 33% and others 60%**

**Time allocation committee for both India and Belgium**

Cycle 2017B (October 2017 to January 2018)

Cycle 2018A (February 2018 to June 2018) and

4KX4K CCD imager (Kumar et al. 2022, JApA 43:27) ,

ADFOSC (Omar et al. 2018) from ARIES and

TIFR NIR imaging camera (TIRCAM2) & TANSPEC

(Editorial in JApA, 2023, 44:18, J.P. Ninan, S. Sharma & S. Vig;

Sharma et al. 2022, PASP, 134::085002 (22p))

Observing proposals are invited and times are allocated

# Belgo-Indian Network for Astronomy and Astrophysics (BINA)

- Since 2016; Support ~ Rs. 55.6 lakhs from DST and 92,767=50 Euros from BELSPO.
- The objective is to increase the interaction between Indian and Belgian researchers by organizing workshops in India and Belgium and mutual work visits from both sides.
- Presently, the BINA network consists of 6 Belgian and 13 Indian partner institutes; goal is to make best use of observations obtained with the 3.6-m DOT; 4-m ILMT and other telescopes as part of multi-wavelength and time domain astronomy.
- Two BINA workshops:- First in India during 15-18 Nov 2016 at ARIES, Nainital. Proceedings published 59 peer reviewed papers in Bulletin de la Société Royale des Sciences de Liège (BSRSL), 2018, vol. 87, 1-397. A one day workshop was organized at Royal Observatory of Belgium (ROB), Brussels (Belgium) on 08 October 2017 followed by 2<sup>nd</sup> BINA workshop from 9 to 12 October 2018. Its proceedings published 39 peer reviewed papers in BSRSL. vol. 88, 1-294. De Cat et al. (2019) & Joshi & De Cat (2019)
- Online ILMT workshop from June 29 to July 1, 2020; organized by ARIES, Nainital. Covid affected

# Joint Supervision of PhD scholars and work visits

As a part of human resource development

- Dr. Brajesh Kumar from ARIES and Dr. Bikram Pradhan from IIST, were trained for the ILMT project and received their PhD from the UL, Liege in November 2014 and January 2020 respectively under the joint supervision led by Prof. Jean Surdej. **So far, ~ dozen PhD students (including Africans) from both sides are trained jointly.** Dr. Otto Trust, Mbarara University of Science & Technology (MUST), Uganda awarded PhD under the joint supervision of Dr. Santosh Joshi and Dr. Peter De Cat **(mandates of DST).**

- **Mobility grant of an Erasmus+ programme for Indian PhD students (8).** Dr. Bharti Arora: as a WBI post-doc grant with Prof. M. De Becker since 1st November 2022 at ULiege.

- In March 2019, Prof. M. De Becker visited IIST (Trivandrum) and NCRA-TIFR, Pune, hosted by Prof. A. Tej and Dr. Ishwara-Chandra respectively. Return visit was made by Prof. A. Tej in Dec 2022.

- Mr. M. Sarkar, a PhD student visited for a month during February-March 2023 hosted by Dr. Peter De Cat and Dr. Patricia Lampense (ROB) and Dr. Marc-Antoine Dupret (ULiege).

- **Publications:- ~30 in peer reviewed journals & ~ 13 in proceedings etc.**

# Successful installation of 4-m class telescopes, largest in Asia

- **The 3.6-m Indo-Belgian DOT:-**The BELSPO contributed 2 million Euros. Observations with the telescope reveal sub-arcsec imaging and excellent performance (Omar et al. 2017; Kumar et al. 2018; Sagar et al. 2019, 2020, 2022). All these led to good numbers of national and international collaborations including BINA (Joshi & De Cat 2019) e.g. to understand formation mechanisms, Arora et al. (2021) carried out NIR and X-ray observations of the colliding-wind binary WR 125 (WC7 + O9III) with the 3.6 m DOT and the AstroSat Soft X-ray Telescope respectively. These new measurements combined with the archival multi-wavelength data were used to study long-term variations in the object. So far, the telescope has contributed to over 100 publications and 6 PhD theses.
- **The 4-m ILMT,** installed in 2022 (Surdej et al. 2022; Kumar et al. 2022a), performs multi-band optical imaging of a narrow strip ( $\sim 220$  arc-sec) of sky. Astrometric and photometric standard candidates published by Dukiya et al. (2022) and Mandal et al. (2020) and data pipeline developed by Kumar et al. (2022b) shall be very useful. Other than the transient astronomy, the ILMT survey will detect and characterize the space debris which is an important input to risk analysis for current and future space missions. Pradhan et al. (2018) found that the 4-m ILMT photometric survey may provide detections of objects having diameters as small as 3 cm in Low Earth Orbit. So far, published over dozen papers and 2 PhD degree (Brajesh Kumar and Bikram Pradhan).

# Key science output from the collaboration

- **Photometric and spectroscopic study of eclipsing binaries** for understanding the formation mechanism of these stars at different stages of their evolutionary phases. In order to unravel the nature of the faint companion of a wide binary system (56 Uma), Escorza et al. (2023) revisited the orbital parameters of the system and carried out a detailed spectral analysis including high-resolution HERMES spectra. This study estimated the mass of the unseen component as  $1.31 \pm 0.12 M_{\odot}$ , which is compatible with both a white dwarf and a neutron star. ([IIA](#), [ARIES](#) and [A. Jorissen](#))
- Magnetic cataclysmic variables (MCVs) are interacting semi detached binaries consisting of a magnetic white dwarf (WD) as the primary and a Roche lobe filling star as the secondary. The magnetic field strength of the WD plays a crucial role in deciding the two distinct subclasses of MCVs: intermediate polars (IPs) and polars. Based on detailed optical and X-ray timing and spectral study of two candidate MCVs, namely 1RXS J174320.1-042953 and YY Sex, Rawat et al. (2023) conclude that both candidates belong to the polar subclass of MCVs. ([ARIES & ULiege](#))

- Gravitational microlensing by compact objects in lensing galaxies is known tool for probing the structure of distant quasars on sub-parsec scales. Hutsemékers et al. (2020) used **ESO, VLT** observations of the two images of the broad absorption line (BAL) quasar SDSS J081830.46+060138.0 (J0818+0601) at redshift  $z = 2.35$ . These observations indicate that J0818+0601 is actually gravitationally lensed, and not a binary quasar.  
(ULiege and ARIES)
- Benaglia et al. (2020) (**GMRT observations at 325 and 610 MHz**) studied 11 early-type stars, located in area of  $\sim 15$  sq degrees centered on the Cygnus region and identified two additional particle-accelerating colliding-wind binaries, namely Cyg OB2 12 and ALS 15108 AB. Group led by De Becker, M. from Belgium is collaborating with scientists from NCRA and IIST and making use of GMRT observing facility.
- Joshi et al. (2022) found that sample of the Nainital-Cape survey classified as constant stars, are now (potentially) identified as variables. This study clearly demonstrate strength of international collaborations as observational data and expertise from many countries including Belgium and India are utilized with a long-term goal of understanding stellar structure and atmospheres of chemically peculiar stars as well as of magnetic fields, inhomogeneities (such as spots), and tidal interaction.

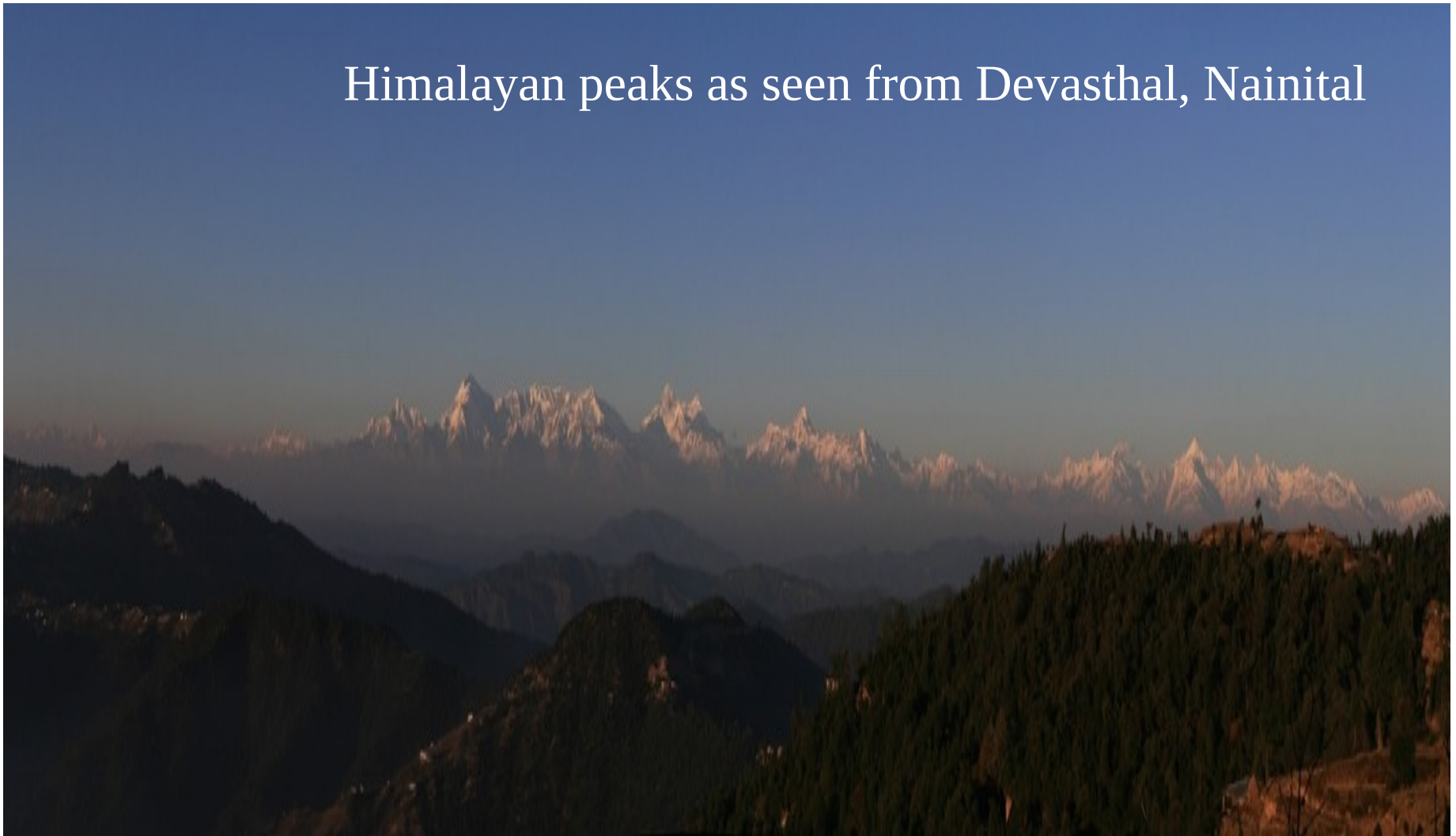
# Summary and Conclusions



**The 4-m ILMT is another jewel in the crown of Devasthal Observatory.**

- Indo-Belgian cooperation contributed to the growth path of Devasthal Optical Observatory. Performance of the 3.6 m DOT is excellent with sub arc sec seeing and images.
- High Resolution Spectrograph & Devasthal Optical Telescope Integral Field Spectrograph are being fabricated by the ARIES and IUCAA respectively.
- Good start; using both ground and space telescopes as part of multi-wavelength astronomy; Hope for bright future of Indo-Belgian collaboration.

Himalayan peaks as seen from Devasthal, Nainital



***Thanks for patient hearing***