

# DEEPAK

Research Associate - II  
Aryabhata Research Institute of Observational Sciences (ARIES), Nainital, India

Email id: [deepak4astro@gmail.com](mailto:deepak4astro@gmail.com) & [deepak.aries@aries.res.in](mailto:deepak.aries@aries.res.in)

Website: <https://sites.google.com/view/deepak-india>

ORCID: <https://orcid.org/0000-0003-2048-9870>

## Education

**Ph.D. in Physics (Astronomy & Astrophysics)** 28<sup>th</sup> March 2023

Institute: Indian Institute of Astrophysics (IIA), Bengaluru, India

(Degree awarded by Pondicherry University (PU), Puducherry, under MoU between IIA and PU)

Thesis title: **Chemodynamic studies of the Galaxy**

Thesis supervisor: Prof. Bacham Eswar Reddy (IIA Bengaluru)

**Master of Science in Physics**, Indian Institute of Technology (IIT), Guwahati - 781039, India 2015

Thesis title: **Experimental Investigation of Cylindrical Vector Beams**

Thesis supervisor: Prof. Bosanta R. Boruah (IIT Guwahati)

**Bachelor of Science (Honours) in Physics**, Kirori Mal College, University of Delhi, Delhi, India 2013

Percentage of marks obtained: 82%

**High School**, Arya Senior Secondary School, Panipat - 132103, India 2010

Percentage of marks obtained: 85%

## Work experience

**Research Associate - II** at ARIES, Nainital - 263001, India. Sept. 2023 - present

**Research Associate - I** at ARIES, Nainital - 263001, India. Sept. 2022 - Sept. 2023

**Senior Research Fellow** at IIA, Bengaluru - 560034, India. July 2017 - March 2022

**Junior Research Fellow** at IIA, Bengaluru - 560034, India. July 2015 - July 2017

## Teaching experience

Course: **Mathematical and Statistical Methods** ARIES Pre. Ph.D. Course Work 2023-24  
*Taught to the first-year PhD candidates (batch of 2023) at ARIES, Nainital - 263001, India, from August to December 2023. In the course, error analysis and various mathematical and statistical methods were covered to get a better idea about the statistical interpretation of data. Brief introductions to programming language MATLAB and PYTHON were also provided. Also, special attention was given to the application of various statistical methods by using relevant examples. For this, regular hands-on sessions were carried out to solve example problems using MATLAB and PYTHON. Finally, assignments consisting of customised example problems in astrophysics were given to enhance the understanding and skill development, which are expected to directly benefit the students in their research careers.*

## Publications

Citations: 108; H-index: 5 (Source: NASA/ADS; Updated: January 2024)

### Publications in peer-reviewed journals:

1. *Lithium in red giants: the roles of the He-core flash and the luminosity bump*

Deepak & Lambert, D. L., 2021, MNRAS, Volume 5.7, Issue 1, pp. 204-225

DOI: <https://doi.org/10.1093/mnras/stab2022>

Highlight: (i) Studied physical and chemical properties of Li-enriched and normal giants based on the largest sample of giants with available Li abundance measurements. (ii) Created customised stellar models using the Modules for Experiments in Stellar Astrophysics (MESA) and tested against the observational data. (iii) Showed that currently available models not only fail to explain Li enrichment in post-He-flash giants but also fail to explain Li's evolution on the red-giant branch. (iv) Provided direct evidence of no Li enrichment at the luminosity bump phase.

2. *Lithium abundances and asteroseismology of red giants: understanding the evolution of lithium in giants based on asteroseismic parameters*  
**Deepak** & Lambert, D. L., 2021, MNRAS, Volume 505, Issue 1, pp.642-648  
 DOI: <https://doi.org/10.1093/mnras/stab1195>  
 Highlight: (i) All the Li-enriched giants are He-core burners. (ii) In some post-He-flash giants, detected unexpectedly lower asteroseismic mass from scaling relations compared to masses estimated from isochrones based on seismic data suggesting possible mass loss during He-core flash. (iii) Found no Li-enrichment near the luminosity bump. (iv) Li in He-core burning giants is found to decrease with an increase in the gravity mode period spacing, which follows an increasing trend with an increase in stars' age soon after He-core flash, further suggesting the enriched Li in He-core burning giants decrease as stars evolve.
3. *Abundance analyses of Li-enriched and normal giants in the GALAH survey*  
**Deepak**; Lambert, D. L. & Reddy, B. E., 2020, MNRAS, Volume 494, Issue 1, pp.1348-1365  
 DOI: <https://doi.org/10.1093/mnras/staa729>  
 Highlight: (i) First-time detailed study of physical and chemical properties of Li-rich and normal giants. (ii) Discovered that the probability of Li-enrichment increases with stars' metallicity but is independent of mass. (iii) Li-rich and normal giants are found to have similar rotational velocities. (iv) Discovered that Li-rich and normal giants are chemically similar except for the abundances of CNO cycle elements suggesting a connection between the Li-enrichment process and CNO cycle.
4. *Study of Lithium-rich giants with the GALAH spectroscopic survey.*  
**Deepak** & Reddy, B. E., 2019, MNRAS, Volume 484, Issue 2, p.2000-2008  
 DOI: <https://doi.org/10.1093/mnras/stz128>  
 Highlight: (i) Discovered 335 new Li-rich giant stars and helped increase the sample of known Li-rich giants in literature by two-fold. (ii) Discovered that most of the Li-rich giants are He-core burning red-clump stars, and helped solve the almost four-decade-old puzzle about the origin of Li-rich giants. (iii) Results helped in testing and discarding many of the previous theories (like planet engulfment and binary interaction) about Li-enrichment in giants.
5. *Radial Velocity Comparison of Gaia DR2 and RAVE DR5 Survey: A Systematic Offset in Radial Velocities among a Group of Highly Accurate Radial Velocity Stars.*  
**Deepak** & Reddy, B. E. 2018, AJ, Volume 156, Issue 4, article id. 170, 6 pp.  
 DOI: <https://doi.org/10.3847/1538-3881/aadcde>  
 Highlight: Compared the two largest RV catalogues and detected a small group of stars with a systematic offset of about 105 km/s when both the catalogues provide typical RV accuracy < 1 km/s. Further showed the impact of such systematic offsets on the chemo-dynamical studies of the Galaxy.  
  
*Publication under review:*
6. *On the Metallicity Gradients in the Galactic Disk using Open Clusters*  
 Joshi, Y. C.; **Deepak** and Malhotra, S., 2023, Frontiers in Astronomy and Space Sciences (Manuscript ID: 1348321)

### Publications in conference proceedings:

1. *Lithium in the Galaxy: current status and contribution from the low-mass giants?*  
**Deepak** & Reddy, B. E., 2020, Memorie della Societa Astronomica Italiana, v.91, p.134-137  
 Bibcode: <https://ui.adsabs.harvard.edu/abs/2020MmSAI..91..134D>  
 Highlight: Studied the evolution of Li in the Galaxy using a sample of about sixty thousand main-sequence dwarf stars. Li is found to have significantly enriched in the Galactic disk compared to old halo stars and also the primordial value suggested by theoretical models. Li in super-solar metallicity stars is found to follow a decreasing trend but unlike common belief, it is not found to be linked to radial migration in the Galaxy.

2. *Lithium enrichment in the Galaxy: A study using the GALAH and Gaia surveys*  
Deepak & Reddy, B. E., 2020, Proceedings of the International Astronomical Union, Volume 353, pp. 16-18  
DOI: <https://doi.org/10.1017/S1743921319008597>

### Conference/meeting presentations (selected)

- *“Lithium in the Galaxy: current status and contribution from the low-mass giants?”* Lithium in the Universe: to Be or Not to Be conference, 18 - 22 November 2019, Observatory of Rome, Monte Porzio Catone, Italy. (Talk)
- *“Lithium enrichment in the Galaxy: A study of RGB stars using the GALAH and Gaia survey,”* IAU Symposium 353, 30 June - 5 July 2019, Shanghai, China. (Poster)
- *“Journey of light elements through the cosmos,”* ARIES Science Club, 26 October 2023, ARIES, Nainital, India. (Talk)
- *“Galactic Archaeology: the Galactic Evolution, Open Star Clusters and Stars’ Giant Phase Evolution,”* colloquium talk titled, 21<sup>st</sup> September 2023, at ARIES, Nainital, India. (Talk)
- *“Formation and Evolution Histories of the Milky Way,”* ARIES Training School in Observational Astronomy (ATSOA 2023), 17 to 28 April 2023, ARIES, Nainital, India. (Talk)
- *“3.9-m AAT’s contribution in addressing the mystery of Li-rich giants’ origin and valuable lessons for 3.6-m DOT,”* 3<sup>rd</sup> BINA Workshop on the Scientific potential of the Indo-Belgian Telescopes, 22 - 24 March 2023, Graphic Era Hill University, Bhimtal, India. (Talk)
- *“Galactic Chemical evolution in the era of the Gaia and large spectroscopic surveys: An overview on Lithium Abundance,”* Gaia Symposium: DR2 and Beyond, 2 - 6 November 2020, IIA Bengaluru, India. (Talk)
- *“Evolution of lithium in the Milky Way,”* Chemical elements in the Universe: origin and evolution, 16 - 19 December 2019, IIA Bengaluru, India. (Talk)
- *“Evolution of lithium in the Milky Way,”* 38<sup>th</sup> Meeting of the Astronomical Society of India, 13 - 17 February 2020, IISER, Tirupati, India. (Poster)
- *“The Galactic Halo: Stellar Populations and Formation History,”* 37<sup>th</sup> Meeting of the Astronomical Society of India, 18 - 22 February 2019, Christ (Deemed to be University), Bengaluru, India. (Talk)
- *“Archaeology of the Galaxy in the Era of Large Astrometric and Spectroscopic Surveys,”* Exploring the Universe: Near Earth Space Science to Extragalactic Astronomy, 14 - 17 November 2018, S. N. Bose National Centre for Basic Sciences, Kolkata, India. (Talk)
- *“Study of stellar populations in the disk of the Galaxy in the Gaia era,”* Galaxy Evolution and Dynamical Structures (GEDS2018), 22 - 25 January 2018, IUCAA, Pune, India. (Poster)

### Research Projects

1. *“Understanding impact of He-core flash on stars’ atmospheres and compositions using NIR spectra from 3.6-m Devasthal Optical Telescope”.* This is an ongoing project. Under this project, we are in the process of collecting and analysing low-resolution spectra for a large sample of giant stars.
2. *“Understanding the Galactic evolution with open star clusters”.* This is an ongoing project and one of the Manuscripts is under review in *Frontiers in Astronomy and Space Sciences*.
3. *“Chemo-dynamic studies of the Galaxy”* under the supervision of Sr. Prof. Bacham Eswar Reddy (IIA, Bengaluru) from April 2017 onwards. Sub-projects *“Galactic lithium evolution”* and *“Evolution of lithium in low-mass stars and their possible contributions towards the Galactic lithium evolution”* are also part of this project. Works in these projects are partially carried out in collaboration with

Prof. Emeritus David L. Lambert (W.J. McDonald Observatory and Department of Astronomy, The University of Texas at Austin, Austin, TX 78712, USA).

4. “*Identifying emission-line objects and understanding the detection limits*” with Dr. Mohammad Akhlaghi of the Centre de Recherche Astrophysique de Lyon (CRAL, in Lyon, France) and Instituto de Astrofísica de Canarias (IAC, in Tenerife, Spain) in August 2019.
5. “*Solar Coronal Magnetic Field Measurement Through Low-Frequency Radio Observations*” under the supervision of Prof. R Ramesh (IIA Bengaluru) from July 2016 to April 2017.
6. “*Experimental Investigation of Cylindrical Vector Beams*” under the supervision of Prof. Bosanta R. Boruah (Indian Institute of Technology Guwahati - 781039, India) from 2014 to 2015 (Master’s thesis).

## Relevant Skills/Experience

- Experience in a) chemical analysis of stars, and b) analysis of kinematic/dynamical properties of stars.
- Experience in analysing and operating on data from large astrometric and spectroscopic surveys.
- Experience in spectroscopic and photometric observations from the 3.6-m Devasthal Optical Telescope and 2-m Himalayan Chandra Telescope (HCT).
- Experience in developing customised stellar models using the Modules for Experiments in Stellar Astrophysics (MESA).
- Programming languages: MATLAB and PYTHON. Have also worked with FORTRAN and extensively used markup language LaTeX.

## Awards/Prizes/Grants/Fellowships

- **First Prize** in the Joint ARIES-IIA Augmenting Writing Skills for Articulating Research (JAI-AWSAR) Competition for the year 2021-2022. **Consolation Prize** in the 2020-2021 competition.
- Senior Research Fellowship (2017-2022) and Junior Research Fellowship (2015-2017) by IIA Bengaluru and Department of Science and Technology, Government of India.
- Merit Scholarship under Scheme of Scholarship for College and University Students by Ministry of Education, Government of India from 2010 to 2015.

## Qualification in some Indian national level examinations

Exam	Conducting institution	Year	All India Rank
Graduate Aptitude Test in Engineering (GATE)	IIT Kanpur on behalf of Ministry of Education, Govt. of India	2015	88
National Eligibility Test for Lectureship/Assistant Professor	Council of Scientific and Industrial Research (CSIR) & University Grants Commission (UGC), Govt. of India	2014	69
Joint Admission test for Masters (JAM)	Indian Institutes of Technology Delhi	2013	239

## References

**Prof. Emeritus David L. Lambert**

*Affiliation:* W.J. McDonald Observatory and Department of Astronomy, The University of Texas at Austin, Austin, TX 78712, USA

*E-mail:* dll@astro.as.utexas.edu

**Sr. Prof. Bacham Eswar Reddy**

(PhD Thesis supervisor)

*Affiliation:* Indian Institute of Astrophysics, Bangalore - 560034, India

*E-mail:* eredy@iiap.res.in