

Varsha Ramachandran

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RESEARCH POSITION

2019 -- 2021

Postdoctoral researcher

Institute for Physics and Astronomy

University of Potsdam, Germany

grant by Deutsches Zentrum für Luft- und Raumfahrt (DLR)

RESEARCH INTERESTS

Stellar Populations Massive Stars, Clusters Magellanic Clouds & Bridge
Binaries Stellar Evolution Wind, Rotation Feedback Star Formation ISM
Chemical abundance Superbubbles & Shells low metallicity dwarf galaxies

EDUCATION

2015 -- 2019

PhD in Astronomy and Astrophysics

Institute for Physics and Astronomy

University of Potsdam, Germany

- Supervisor: Prof. Wolf-Rainer Hamann
- Ph.D. Thesis: Massive star evolution, star-formation and feedback at low metallicity : Quantitative spectroscopy of OB stars in the Magellanic Clouds
- Grade: with great honor ("magna cum laude")

2013 -- 2015

M.S.in Astronomy and Astrophysics

Indian Institute of Space Science and Technology, Kerala, India

- Supervisor: Prof. Anandmayee Tej
- Master's Thesis : Radio and Infrared study of Galactic star-forming region IRAS 20286+4105
- CGPA: 8.81/10 (Topper)

2009 -- 2013

B.Tech in Electronics and Communication

NSS Engineering College, Kerala, India

- CGPA: 7.9/10

Grants/Funding

2019 -- 2021

Post doctoral funding by DLR: 150k EUR

2015 -- 2019

PhD Funding by Deutscher Akademischer Austauschdienst (DAAD): 50k EUR

Bridge Scholarship Programme from University of Potsdam (declined)

2013 -- 2015

Graduate Aptitude Test in Engineering (GATE) scholarship (in top 2%)

Research funding from German Research Foundation (DFG) - submitted (written, Co-I)

AWARDED TELESCOPE TIME

- Gran Telescopio CANARIAS*
- DDT time for "Simultaneous GTC - HST (and XMM-Newton) observations of the most massive high mass X-ray binary" using MEGARA IFU (Writer; Co-I) - *2hrs*
- Hubble Space Telescope*
- HST Cycle 28 GO proposal as PI get into first quartile
 - Co-I of accepted GO program 16182 in HST Cycle 28 "UV spectroscopy of a bona fide ultra-luminous X-ray source" - *17 orbits*
 - Co-I of accepted GO program 16170 in HST Cycle 28 "Wolf-Rayet stars in the outskirts of M33" - *20 orbits*
 - Co-I of accepted GO program 16272 in HST Cycle 28 "The multiplicity and properties of the LMC WC stars" - *24 orbits*
 - Co-I of accepted GO program 15837 in HST Cycle 27 "COS UV survey of the most massive O-stars in the SMC" - *18 orbits*
- European Southern Observatory*
- Co-I of accepted ESO/VLT program 0106.D-0321(A) "First spectroscopic study of the complete sample of WR stars in the metal poor dwarf galaxy IC 1613" - *15.6 hrs*
 - Co-I of accepted ESO/VLT programs 0105.D-0355(A) and 0105.D-0355(B) "X-SHOOTER survey of the most massive O-stars in the SMC" - *total 45.2 hrs*
 - Co-I of accepted ESO/VLT programs 0103.D-0921(A) and 0104.D-0225(A) "Uncovering the role of binarity in the evolution of massive star at low metallicity using multi-epoch VLT FLAMES survey" - *total 84 hrs*
- XMM-Newton*
- Co-I of accepted XMM-Newton Proposal 088375 "Bringing stripped stars to X-ray light" - *148ks*
- Southern African Large Telescope*
- Co-I of SALT program 2016-2-SCI044, long slit H α spectroscopy of Eastern Wing of the Small Magellanic Cloud.

OBSERVATIONAL EXPERIENCE

- Experience in phase I, II, III stages of ESO/VLT, HST and GTC observations
- Joint HST/COS and XMM/EPIC spectroscopy of the X-ray binary in M33 : participated in phase II, phase III
- ESO/VLT-FLAMES programs 086.D-0167(A) and 096.D-0218(A): participated in selection of objects, data reduction.
- Radio continuum observations at 610 and 1280 MHz with Giant Meter-wave Radio Telescope (GMRT), on-site participation, data reduction
- NIR narrow-band imaging using the TIFR Near-Infrared Spectrometer and Imager (TIRSPEC), in the Br γ and K-Cont narrow-band filters

RESEARCH VISIT/ TRAVEL GRANTS

- Visiting grant by Department of Astronomy, University of Wisconsin-Madison
- Funding by Potsdam Graduate School, DLR, DAAD
- Travel grant by Olympian Symposium, Astronomische Gesellschaft
- Funding for 3 month research stay at the National Centre for Radio Astrophysics (NCRA) and GMRT facility, Pune.

PROFESSIONAL MEMBERSHIPS

- Young member in International Space Science Institute ISSI working group, Multi-wavelength View on Massive Stars in the Era of Multimessenger Astronomy
- Member of ULLYSES-XShooter working subgroups/collabrations
- Member of Potsdam Graduate School (PoGs) network
- Member of Leibniz graduate school for quantitative spectroscopy

TEACHING EXPERIENCE

- Mentoring PhD and master students, resulting in publications
- Two week lectures on "Measuring cosmic distances" and "X-ray from stars" for master students, 2018
- Assisting students with Stellar atmosphere modeling using PoWR
- Exercise classes on "Stars & Stellar structure" and conducted exams for master students, 2016-2017
- Lab assistance on "familiarizing IRAF" for bachelor students, 2014
- Lab assistance in astronomy winter school, IIST, 2014

TECHNICAL SKILLS

Astronomical tools & software

- PoWR : A state-of-the-art stellar atmosphere code suitable for the spectroscopic analysis of hot stars, extensively used for analysis, constructed grids of models with various stellar parameters
- ESO Common Pipeline Library, Gasgano : Experienced with data reduction
- GTC/ MEGARA data reduction pipeline : Used for reduction of integral field data in different spectra settings
- WRplot : Plotting and data visualization
- Iacob-broad tool : Familiarity in using the IDL code for finding projected rotation velocity of OB stars
- Topcat: Extensively used to cross correlate catalogs and databases.
- AIPS : Editing, imaging & self-calibration of raw radio uv data, and generating 1280 & 610 MHz radio maps
- IRAF : Familiarity in photometry of optical and IR data, image reduction, spectral data, reduction using TIRSPEC pipeline
- HIPE : Used to work with Herschel data, including finding the data products, interactive analysis, plotting of data, and data manipulation
- DS9, fv, Aladin, Greg GILDAS : Used to visualize and analyze images

Programming

- Python : Most of the data analysis and visualizations are implemented using python. Extensively using pandas, astropy, matplotlib, scipy, seaborn etc.
- Jupyter notebooks : Using to extract & normalize spectra and for interactive visualization
- Completed course work in C++, C programming. Numerical simulations & computations were done in C++ (MS).
- Familiarity in FORTRAN; used to develop a subroutine to extract the target spectrum in the HST-COS fov by removing contamination from nearby sources

RESEARCH EXPERIENCE

Post Doc

- Joint HST/COS, GTC/MEGARA and XMM/EPIC spectroscopy of the high mass X-ray binary in M33

- Data acquisition, reduction and analysis with HST, GTC and XMM-Newton spectra and image
- PoWR models for O star in HMXB during different orbital phases
- Analysis of metal poor OB stars in the outskirts of Milky Way using UVES
- Spectral analysis of LB-1 system (Be and stripped star) using PoWR model
- Combined UV+optical analysis of massive binaries at different metallicities
- Taking part in the study of combined MUSE+HST UV study of OB stars in most massive SMC cluster NGC346
- First discovery of O stars in the Magellanic Bridge
 - Multi-epoch spectra, binary analysis
 - Detailed chemical abundance analysis, Chemical evolution to constrain interaction between the Magellanic Clouds
 - Gaia and Galex color-magnitude diagrams
 - Feedback from hot stars to the diffuse ISM, escape fraction

Ph.D. Thesis *Massive star evolution, star-formation and feedback at low metallicity*

- Observation and data reduction of VLT FLAMES spectra
- Expertise in using the Potsdam Wolf-Rayet (PoWR) model atmosphere. Constructed grids of models with various stellar parameters at SMC and LMC metallicity.
- Spectral classification of OB stars
- Spectroscopic analyses of ~ 500 low metallicity OB stars in Magellanic Clouds; analysis of optical and UV (HST/IUE/FUSE) data
- Binary analysis of Wolf-Rayet + O system
- Studied weak winds of OB stars at low metallicity
- Rotational velocities of stellar population, Be stars
- Radial velocity studies and runaway stars
- Chemical abundance analysis, nitrogen enrichment
- Empirical Hertzsprung-Russell diagram of LMC and SMC massive stars
- Star formation modes and history
- Calibrating ionizing photons vs. spectral subtype
- Energy-momentum feedback estimation from supernovae
- Energy budget calculation of superbubble and supergiant shell complex, comparison with observations (X-ray, radio, and optical)
- Formation of large scale ISM structures: superbubbles and supergiant shells
- Familiarity in working with Nebula spectra (HII region, SNR, X-ray bubble)
- Constructing expansion velocity, electron density maps of ionized gas

M.S Thesis *Understanding high mass star formation in Galactic star-forming regions*

- Radio data reduction and analysis using AIPS at 610, 1280 & 4860 MHz
- Sources associated with IRAS 20286+4105 using the 2MASS, Spitzer IRAC, and UKIDSS data
- Cluster studies using star count and nearest neighbor (NN) density algorithms
- Population of YSO using color-color and color-magnitude diagrams and their respective SED modelling
- Characteristics of NIR Br- γ , H₂, and H α emission, NIR spectroscopy of MYSOs
- Derived dust temperature and column density maps from FIR Herschel data
- Dust emissivity and dust temperature inverse relationship
- Identification of star forming clumps and mass calculation
- PAH emission in the region from Spitzer IRAC band ratios

CONFERENCE/
SEMINAR
CONTRIBUTIONS
Talks

- Contributed talk in annual meeting of the Astronomische Gesellschaft 2020, "Massive star feedback in the Magellanic Clouds and the Bridge"
- Invited colloquium talk in University of Wisconsin-Madison 2020 (postponed due to covid)
- Invited seminar talk in Theoretical Astroparticle Physics, University of Potsdam, 2019 December, "Bubbles around massive stars"
- Contributed talk in StarFormMapper 2019 Conference, September 2019, York (UK), "Stellar feedback powering star-forming complexes in the Magellanic Clouds"
- Contributed talk in European Week of Astronomy and Space Science (EWASS), Lyon, June 2019, "A dichotomy in the evolution of massive stars at low metallicity"
- Contributed talk in EWASS, Lyon, June 2019, "Massive stars and ionized gas content in the N206 superbubble in the LMC"
- Contributed talk in The Olympian Symposium, Greece, May, 2018, "Probing star-formation and feedback in superbubbles and supergiant shells"
- Contributed talk in annual meeting of the Astronomische Gesellschaft, Goettingen, September, 2017, "Stellar population of the superbubble N206 in the LMC"
- Seminar talk in Astrophysical Seminar, University of Potsdam, June 2017, "Feedback from young stellar clusters: 'Of' stars in the superbubble N206 in the LMC"
- Contributed talk in ISM-SPP Student Workshop, Freising, March, 2016, "Spectra and feedback from young stellar clusters"

Posters

- "Probing massive star evolution, star formation, and feedback in the Magellanic Cloud", A synoptic view of the Magellanic Clouds, September 2019, ESO Garching
- "Star formation and feedback at low metallicity", EWASS, Lyon, June 2019
- "Stellar feedback powering star-forming complexes in the Magellanic Clouds", 15th Potsdam Thinkshop, September 2018
- "Spectra and feedback from young stellar clusters", EWASS, Prague, June 2017
- "Radio and infrared study of star-forming region IRAS 20286+4105", Star and Planet Formation workshop, December, 2016, Trivandrum, Kerala
- "Radio and infrared study of star-forming region IRAS 20286+4105", Current trends in Near Infrared Astronomy in India, Hyderabad, November, 2014

Organizer

- Conference organizer (LOC) "Potsdam Astrophysical Summer School", 2016
- Workshop organizer (LOC) astronomy winter school, IIST, 2014

REFEREED
PUBLICATIONS

First author
publications

- **Ramachandran, Varsha**, Oskinova, L. M. And Hamann, W. -R. 2020, A&A, (Forthcoming article). "Discovery of O stars in the tidal Magellanic Bridge: Stellar parameters, abundances, and feedback of the nearest metal-poor massive stars and their implication for the Magellanic System ecology". DOI:10.1051/0004-6361/202039486
- **Ramachandran, V.**, Hamann, W. -R., et al. 2019, A&A, 625, A104. "Testing massive star evolution, star formation history, and feedback at low metallicity. Spectroscopic analysis of OB stars in the SMC Wing". DOI:10.1051/0004-6361/201935365

- **Ramachandran,V.**, Hamann, W. -R., et al. 2018, A&A, 615, A40. “Stellar population of the superbubble N 206 in the LMC. II. Parameters of the OB and WR stars, and the total massive star feedback”. DOI:10.1051/0004-6361/201832816
 - **Ramachandran,Varsha**, Hainich, R., et al. 2018, A&A, 609, A7. “Stellar population of the superbubble N206 in the LMC. I. Analysis of the Of-type stars”. DOI:10.1051/0004-6361/201731093
 - **Ramachandran,Varsha**, Das, S. R., et al. 2017, MNRAS, 465,4.“Radio and infrared study of the star-forming region IRAS 20286+4105”. DOI:10.1093/mnras/stw2906
- Co-author publications
- Liu, Jifeng., ..., **Ramachandran,Varsha.** et al. 2019, Astrophysical Journal, 900,42. “Phase-dependent Study of Near-infrared Disk Emission Lines in LB-1”. DOI:10.3847/1538-4357
 - Fulmer, Leah M., ..., **Ramachandran,Varsha.** et al. 2020, A&A, 633, A164. “Testing massive star evolution, star-formation history, and feedback at low metallicity. Photometric analysis of OB stars in the SMC Wing”. DOI:10.1051/0004-6361/201834314
 - Shenar, T., ...,**Ramachandran,Varsha** et al. 2019, A&A, 627, A151. “The Wolf-Rayet binaries of the nitrogen sequence in the Large Magellanic Cloud. Spectroscopy, orbital analysis, formation, and evolution”. DOI:10.1051/0004-6361/201935684
 - Hamann, W. -R., ..., **Ramachandran,V.** et al. 2019, A&A, 625, A57. “The Galactic WN stars revisited. Impact of Gaia distances on fundamental stellar parameters”. DOI:10.1051/0004-6361/201834850
 - Hainich, R., **Ramachandran,V.** et al. 2019, A&A, 621, A85. “PoWR grids of non-LTE model atmospheres for OB-type stars of various metallicities”. DOI:10.1051/0004-6361/201833787
 - Gruner, D., ..., **Ramachandran,V.** et al. 2019, A&A, 621, A63. “The extreme O-type spectroscopic binary HD 93129A. A quantitative, multi-wavelength analysis”. DOI:10.1051/0004-6361/201833178
 - Sander, A. A. C., ...,**Ramachandran,Varsha** et al. 2019, A&A, 621, A92. “The Galactic WC and WO stars. The impact of revised distances from Gaia DR2 and their role as massive black hole progenitors”. DOI:10.1051/0004-6361/201833712
 - Shenar, T., ...,**Ramachandran,Varsha** et al. 2018, A&A, 616, A103. “The shortest-period Wolf-Rayet binary in the Small Magellanic Cloud: Part of a high-order multiple system. Spectral and orbital analysis of SMC AB 6”. DOI:10.1051/0004-6361/201833006

**SUBMITTED/
NON-REFEREED
PUBLICATIONS**

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- Gilkis, A., Shenar, T., **Ramachandran,V.** et al. 2020, MNRAS, (submitted). “The excess of cool supergiants from contemporary stellar evolution models defies the metallicity-independent Humphreys-Davidson limit”
 - Hamann, W. -R., ..., **Ramachandran,V.** et al. 2017, IAU Symposium, 329, 223 “Massive stars in advanced evolutionary stages, and the progenitor of GW150914”
 - Fulmer, L. M.,...,**Ramachandran, V.**, et al. (2018), AAS 231, 348. “Skyscrapers in the Desert: Observing Ongoing, Active Star Formation in the Low-Density Wing of the Small Magellanic Cloud”
 - Fulmer, L.,...,**Ramachandran, V.**, et al. (2017), AAS 229, 154. “Stellar Evolution of the Star Cluster NGC 602 and Massive Star Formation in the Low-Density Wing of the SMC”