Curriculum Vitae

SHUBHONKAR PARAMANICK

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https://shubhonkar-paramanick.github.io/

https://github.com/Shubhonkar-Paramanick

RESEARCH INTERESTS

Exoplanet Formation, Dynamical Evolution, Detection, and Characterization; Exoplanetary Atmospheres; Orbits and Dynamics; Habitability

EDUCATION

Bachelor of Technology, Physical Sciences

Aug. 2013 – May 2017

Indian Institute of Space Science and Technology (IIST)
Thiruvananthapuram, Kerala, India

- Cumulative GPA : 8.91 (On a 10-point Scale); 3.76 (On a 4-point Scale)
- Final Year Average : 9.59 (On a 10-point Scale); 4.00 (On a 4-point Scale)
- Department Rank : 2
- Relevant Undergraduate Courses : Introduction to Astronomy and Astrophysics; Electromagnetic Theory and Relativity; Classical Mechanics; Quantum Mechanics; Statistical Mechanics; Atomic, Molecular and Nuclear Physics; Linear Algebra; Numerical Analysis; Differential Equations; Probability and Statistics; Pattern Recognition
- Graduate Level Electives : Radiation Process in Astrophysics; Cosmology and Astro Biology; Planetary Geosciences; Atmospheric Radiation and Climate

High School

June 2011 – May 2013

Montfort Senior Secondary School
Roorkee, Uttarakhand, India

- Major : Physics, Chemistry, Mathematics, and Biology
- All India Senior School Certificate Examination, Central Board of Secondary Education (CBSE), Score : 96%
- Graduated in the top one percent of High School students in India with a State Rank of 8.

- Secured a State Rank of 34 out of over 25,000 students in the Joint Entrance Examination conducted by IIT (IIT-JEE – 2013).

Secondary School *Apr. 2009 – June 2011*

Holy Cross Secondary School
Haridwar, Uttarakhand, India

- Major : Physics, Chemistry, Mathematics, and Biology
- All India Secondary School Examination, CBSE, Cumulative GPA : 10/10

TEST SCORES

GRE Physics Test *Oct. 2018*

- Scaled Score : 980/990 Percentile : 95

WORK EXPERIENCE

Scientist 'SC' *Aug. 2017 to date*

U R Rao Satellite Centre,[1] Bangalore, India
Indian Space Research Organization (ISRO)
Department of Space, Government of India

KEY PROJECTS

■ **Study of Habitable Planet Earth (SHAPE): Earth as an Extrasolar Planet**[2]

- Leading the science team to simulate the photometry and spectroscopy of the reflected light of Earth as observed from lunar orbit.
- Modeled the photometric light variations of Earth with temporally changing albedo over different latitudes and longitudes.
- Characterized the Acousto-Optics Tunable Filter (AOTF) and the optics of the instrument with the calibration team.[3]
- Disc-integrated reflected light observations of Earth will serve as a benchmark that will help us to compare habitable exoplanets with our home planet Earth. Observations will be carried out using a broadband NIR Spectro-polarimeter aboard ISRO's Chandrayaan-3.
- Development towards Direct Imaging of Exoplanets: Direct imaging of exoplanetary systems will yield the true population statistics as opposed to the indirect detection methods, which render biased statistics towards massive exoplanets. It will also be possible to unveil the habitable zone planets and their properties using this technique.

■ **Aditya - L1 — First Indian mission to study the Sun**

- Computed the spectral and total irradiances and the variations in them for different states of the Sun (active and quiet) by utilizing the spectral synthesis models of the broad spectral bands.

[1] Formerly known as ISRO Satellite Centre. [2] SHAPE [3] Classified Work

- Designed and developed the test setup for the test and calibration of the Solar Ultraviolet Imaging Telescope (SUIT) planned for the Aditya-L1 mission.[4]
- SUIT will image the spatially resolved solar photosphere and chromosphere in the near-ultraviolet (200 - 400 nm) regime and measure the variations in the solar irradiance from the first Lagrangian point.

RESEARCH EXPERIENCES

PROJECTS AND THESES

■ Research Project *July 2020 – Oct. 2020*

Indian Space Research Organisation (ISRO), Bangalore

- Title : **'Analytical Derivation and Numerical Calculation of the Rossiter–McLaughlin (RM) Effect for Transiting Exoplanetary Systems: Perturbative Expansion and Comparison with Simulated and Actual Data'**
- Developed a theoretical framework to determine the asymmetric distortion in the line profiles of the stellar spectrum resulting in an apparent anomaly in the radial velocity curves because of the stellar spin during a planetary transit (RM effect).[5]
- Estimated the stellar spin angular velocity and its direction angle with respect to the orbital axis of the planetary companion transiting HD 209458.
- Derived the exact analytic formulae for the radial velocity (RV) anomaly considering an ideal case of a uniform stellar intensity model.
- Obtained the approximate (but accurate) analytic expressions for the anomaly in the RV curves of exoplanetary systems taking into account the stellar limb-darkening effect, both during the transit and the ingress/egress phases.
- Examined the sensitivity of the radial velocity anomaly to the parameters of the planetary system and determined the numerical accuracy of the analytic expressions (using Monte Carlo with importance sampling and with the Metropolis–Hastings algorithm) by applying the analytic templates to the HD 209458 system.[6]
- Evaluated the uncertainties of the fitted parameters and their correlations by creating mock samples for the RV profiles of HD 209458.
- Demonstrated the efficiency and robustness of the estimated spin parameters by combining the analytic expressions with the HIRES data of HD 209458.
- Study is useful in inferring about the origin and evolution of spin angular momentum in extra-solar planetary systems.

■ Research Project *Aug. 2020 to date*

Indian Space Research Organisation (ISRO), Bangalore

- Title : **'Modeling the Photometric Light Curves of Exoplanets'**
- Analyzed the nature of photometric light curves produced by exoplanetary systems by connecting the orbital and physical parameters of exoplanets to their signatures on the

[4] Classified Work [5] Analytic Description of the RM Effect [6] Numerical Analysis of the RM Effect

transit and photometric light variations.

- Modeled the reflected light from different positions on an exoplanet transiting its uniform far-off host star using plane parallel rays for the incident stellar light.[7]
- Derived and modeled the exoplanet's thermal light by considering its day- and night-side emitting at their respective blackbody temperatures.[8]
- Analyzing the reflected planetary intensity distribution as a function of phase for close-in exoplanets by taking into account the finite angular size of the host star for which the plane parallel ray model of incident stellar radiation breaks down.
- Constructed a three-zone template, viz., fully illuminated by starlight, penumbral, and un-illuminated zones to determine the reflected light distribution, as opposed to the illuminated and un-illuminated zones present in the plane parallel ray model.

■ Research Project *May 2020 – July 2020*

Indian Space Research Organisation (ISRO), Bangalore

- Title : **'Characterization of Extrasolar Planets using the Radial Velocity Method'**
- Theoretically modeled the radial velocity variations of the stars, HAT-P-7 and Pegasi 51, as a function of the known variable (stellar mass) and the unknown variables (inclination angle, planetary mass, and the rotation period).
- Constructed the codes that work both for circular and eccentric orbits in order to fit the actual data (taking into account the data uncertainties) obtained from different spectroscopic observations and understand the planetary systems.
- Derived the closed-form expressions for the general and weighted non-linear and linear least squares regression to the RV profiles.[9]
- Worked out the relationship between the curvature/Hessian matrix and the error of the fit as a function of the independent variable.
- Derived and numerically optimized the parameters non-linearly using the Gauss-Newton iteration and the Levenberg-Marquardt algorithm.
- Estimated the parameters of the Gaussian probability density function by maximizing the likelihood function and computed the effect of variables' uncertainties on the uncertainty of the likelihood function so that under the assumed statistical model, the RV data is most probable.[10]
- Obtained the degeneracies associated with the model by generating a 4-D map of the likelihood function and analyzing the different planar views of the volumetric data over a large parameter space.
- Generatively modeled the data using Markov Chain Monte Carlo (MCMC) by performing the probabilistic inferences and sampling the posterior distribution around the optimum values in order to determine the associated uncertainties on the sampling estimate and understand the multi-modalities in the data.[11]

[7] Modeling of Reflected Light [8] Modeling of Emitted Light [9] Least Squares GitHub Links: [1], [2], [3] [10] ML Estimation GitHub Link [11] MCMC GitHub Link

■ Research Project

Sep. 2020 to date

Advisor: Dr. Arvind Singh Rajpurohit

Physical Research Laboratory (PRL), Ahmedabad

- Title : **'Study of Thermal Emission from the Transiting Exoplanet WASP-12b'**
- Investigating the influence of different atmospheric $\frac{C}{O}$ ratios on the composition and spectra of extrasolar giant planets.[12]
- Generated models to explore a wide $\frac{C}{O}$ abundance range varying from 0.54 to 1.514 at the solar metallicity, assuming a planet-wide redistribution of the absorbed flux.
- Comparatively analyzed the models with similar other models assuming no redistribution of the absorbed flux in order to maximize the day-side temperature.
- Estimated the flux densities of the spectra by performing the synthetic photometry in SPITZER/IRAC and HST/WFC bands.

■ Junior Thesis and Student Intern

May 2016 – July 2016

Advisor: Dr. Neeraj Gupta

Inter–University Centre for Astronomy and Astrophysics (IUCAA), Pune

- Title : **'Kinematic Modeling of Galaxies through HI 21 cm Line Observations'**
- Work done as a part of the Vacation Students' Programme (VSP 2016).
- Analyzed the data from a single–dish (GBT, West Virginia) and an array of antennae (WSRT, ASTRON).
- Derived the exact expressions for the HI mass and the column density of a warped edge-on galaxy (NGC 4013) for both optically thin and thick mediums.
- Computed the HI mass and the column density of the galaxy from the integrated line flux using the single-dish and interferometer data.
- Modeled the antennae field patterns for a uniform linear array of N elements.
- Modeled and studied the kinematics of NGC 4013 utilizing zeroth, first and second moment maps after WSRT data processing and calibration.
- Generated the HI rotation curve of NGC 4013 using the 'Solid Body' and the 'Brandt Rotation Curve Model'. Estimated the observed onset radii for the warps in the edge-on system.

■ Undergraduate Major Course Project

Oct. 2016

Dept. of Earth and Space Sciences, IIST, Trivandrum

- Title : **'Determination of the Cosmological Density Parameters based on Type Ia Supernova Redshifts'**
- Work done as a part of the 'Cosmology and Astrobiology' course project.
- Analyzed the data of 583 different Type Ia supernovae obtained from the High-Z Supernova Search and the Supernova Cosmology Project (SCP).

[12] Thermal Emission of WASP-12b

- Constricted the systematic uncertainties related to the data using a Bayesian hierarchical model.
- Determined the Cosmological Density Parameters (Ω_Λ and Ω_m) by minimizing the χ^2 / maximizing the log-likelihood function.

■ **Senior Thesis** *Dec. 2016 – May 2017*

Advisor: Dr. V.J. Rajesh

Dept. of Earth and Space Sciences, IIST, Trivandrum

- Title : **'Spectral and chemical characterization of Copiapite and Rozenite: Implications for hydration processes on Mars'**
- Analyzed the CRISM and HiRISE datasets of different Martian regions.
- Carried out the VNIR, TIR, FTIR spectroscopy, Laser Raman, and X–ray diffraction analyses. Interpreted and quantitatively matched the absorption spectra, emission bands, and the vibration modes in the lattice with the reference database using different matching algorithms.
- Outlined the astrobiological significance of secondary sulfates' detection on Mars.

PAYLOAD PROPOSAL

- **Proposed a Laser Raman Spectrometer for the Mars Orbiter Mission (MOM-2) of ISRO** to study the Martian surface.

INTERNSHIPS AND WORKSHOPS ATTENDED

■ **Student Intern** *Dec. 2015 – Jan. 2016*

Advisor: Dr. Apoorva Nagar

Dept. of Physics, IIST, Trivandrum

- Title : **'Analysis of Driven, Duffing Oscillator and the study of Chaotic Dynamics'**
- Investigated the dependence of the amplitude and phase lag of a driven oscillator on its driving frequency.
- Analyzed the periodic change of the chaotic attractor of the duffing oscillator for undamped, weakly forced, and periodically forced systems.
- Simulated the damped driven harmonic oscillator and confirmed the chaotic behavior using a Poincaré section.

■ **Student Intern** *June 2015 – July 2015*

Supervisor: Dr. Sanjay Kumar Mishra

Instruments Research and Development Establishment, Defence Research and Development Organization, Dehradun

- Title : **'Measurement and interpretation of Point Spread Function (PSF) due to Diffraction by a Circular Aperture'**
- Studied the diffraction by a circular aperture in the Fresnel and Fraunhofer regions. Numerically determined the locations of maxima and minima of the Airy pattern by solving the Bessel function of the first kind of order one.

- Computed the radius of the Airy disk and verified the linear dependence of half-angle beam spread on the $f_{\#}$ by capturing the PSF images with a CCD camera.

■ **Workshops**

- **'Multi-wavelength observations using Astrosat'** workshop organized by IUCAA, Pune (December 2017)
- '**Radio Astronomy School – 2019'** held at the National Centre for Radio Astrophysics (NCRA-TIFR), Pune (August 2019)

PEER–REVIEWED JOURNAL ARTICLES

- **Shubhonkar Paramanick**, V.J. Rajesh, M.N. Praveen, K.S. Sajinkumar, and Satadru Bhattacharya. Spectral and Chemical Characterization of Copiapite and Rozenite from Padinjarathara in Wayanad, Southern India: Implications for Mars Exploration. *Chemical Geology,* 120043: 1 – 23, December 2020. doi: 10.1016/j.chemgeo.2020.120043. URL http://www.sciencedirect.com/science/article/pii/S0009254120305829. In Press, Reference No.: CHEMGE 120043 (Senior Thesis).

ARTICLES UNDER PREPARATION

- A. S. Rajpurohit; [et al., including **Paramanick, Shubhonkar**]. Thermal inversion in the atmosphere of WASP-12b.
- **Paramanick, Shubhonkar**. Analytical Derivation and Numerical Calculation of the Rossiter – McLaughlin (RM) Effect for Transiting Exoplanetary Systems: Perturbative Expansion and Comparison with Simulated and Actual Data.

OTHER REFEREED CONTRIBUTIONS [ADS]

- Jaiswal, Bhavesh; [et al., including **Paramanick, Shubhonkar**] (2020). Spectro-polarimetric Signatures of Earth in Near-Infrared: A Science Case. Submitted. *AASTCS 8: Habitable Worlds 2021. Nexus for Exoplanet System Science (NExSS).* URL https://aas.org/meetings/aastcs8/habitable. International Conference. Oral Presentation (Work Experience).
- **Paramanick, Shubhonkar***; V.J., Rajesh; Praveen, M. N.; K. S., Sajin Kumar; Bhattacharya, Satadru (2018). Spectral and Chemical analyses of probable Martian analogue minerals, Copiapite and Rozenite: Implications for hydration processes on Mars. *42^{nd} Committee on Space Research Scientific Assembly, Pasadena, CA. B4.1-0023-18, pp. 441–442.* URL http://adsabs.harvard.edu/abs/2018cosp...42E2580P. International Conference. Refereed Paper, Oral, and Poster Presentation (Senior Thesis).
- **Paramanick, Shubhonkar***; V.J., Rajesh; Praveen, M. N.; K. S., Sajin Kumar (2018). Spectral Characterization of Copiapite and Rozenite and its implications. *49^{th} Lunar and Planetary Science Conference, LPI, Texas. LPI Contrib. No. 2083, Volume: 49, #2299.* URL https://www.hou.usra.edu/meetings/lpsc2018/pdf/2299.pdf. International Conference. Refereed Paper and Poster Presentation (Senior Thesis).

*Presenting Author

NON-REFEREED CONTRIBUTIONS

- **Paramanick, Shubhonkar*** (2019). Design and Development of Registration and Collinearity Test Bench for Test and Evaluation of SUIT instrument. *Technical Report, ISRO (Restricted & Confidential) pp. 1–62.* Indian Space Research Organisation (Work Experience).
- **Paramanick, Shubhonkar*** and Narayanan, Anand (2016). Determination of the Cosmological Constant based on Type Ia Supernovae Redshifts. *Research Report. pp. 1–59.* Indian Institute of Space Science and Technology (Undergraduate Work).
- **Paramanick, Shubhonkar*** and Gupta, Neeraj (2016). Kinematic modeling of galaxies through HI 21 cm line observations. *Research Report. pp. 1–174.* Inter-University Centre for Astronomy and Astrophysics (Junior Thesis).
- **Paramanick, Shubhonkar*** and Lekshmi, Resmi (2016). Polarization states of time-varying E-field. *Research Report. pp. 1–28.* Indian Institute of Space Science and Technology (Undergraduate Work).
- **Paramanick, Shubhonkar*** (2016). Evidence of Water on Moon — Results from Chandrayaan-1. *Study Report. pp. 1–47.* Indian Institute of Space Science and Technology (Undergraduate Work).
- **Paramanick, Shubhonkar** and Nagar, Apoorva (2016). Analysis of Driven, Duffing Oscillator and the study of Chaotic Dynamics. *Research Report. pp. 1–24* (Undergraduate Work).
- **Paramanick, Shubhonkar*** and Mishra, Sanjay (2015). Measurement and Interpretation of Point Spread Function due to Diffraction by a Circular Aperture. *Technical Report. pp. 1–76.* Defence Research and Development Organisation (Sophomore Thesis).

PRESENTATIONS AT INTERNATIONAL CONFERENCES

- 42nd Committee on Space Research Scientific Assembly, Pasadena, CA, USA. August 2018.
- 49th Lunar and Planetary Science Conference, Lunar and Planetary Institute, TX, USA. March 2018.

SKILLS

TECHNICAL SKILLS

- **Programming Languages :** C, C++, Python, MATLAB, Fortran, IDL, JavaScript.
- **Markup Languages :** LaTeX, HTML5, CSS, Sass.
- **Operating Systems :** Linux, Windows, Mac OS (X).
- **Applications/Astronomy Packages :** Astropy, Git, Astronomical Image Processing System (AIPS), Common Astronomy Software Applications (CASA), CIAO, HEASoft, SAOImage DS9, MayaVi, IRAF, SimuLink, Mupad, Matplotlib, Mathematica, Gnuplot, Microsoft Office Suite.

LANGUAGES

- English and Hindi (Full professional proficiency, Conversationally fluent).

SCHOLARSHIPS, AWARDS, AND HONORS

- Department Rank (B.Tech. in Physical Sciences) : 2.
- Awarded *IIST Academic Scholarship* based on the academic performance in the undergraduate program, 2013-2017 — funded by the Department of Space (DOS), Government of India.
- Awarded *DOS Book Grant Assistantship* for the bachelor's program, 2013-2017.
- Awarded *Summer Research Fellowship* by the Jawaharlal Nehru Centre For Advanced Scientific Research (JNCASR), Bangalore, in 2016.
- Awarded *Vacation Students' Programme Fellowship* by the Inter-University Centre for Astronomy and Astrophysics (IUCAA), Pune, in 2016.
- Received the *INSPIRE Scholarship* for Higher Education (SHE) from the Department of Science and Technology (DST), Government of India, for the year 2013.
- Qualified the Joint Entrance Screening Test (JEST) in 2017 (for admission to the graduate schools in India).

PROFESSIONAL AFFILIATIONS

- Life Member of the Astronomical Society of India (Membership No.: L2321).
- Member of the American Astronomical Society (Member ID: 69226).
- Member of The Planetary Society (Membership ID: 762883).

UNIVERSITY SERVICE AND OUTREACH ACTIVITIES

- Co-organizer, World Space Week Celebration – 2018 at URSC, Bangalore.
- Team member, 'Nirmaan' outreach program, IIST (2015-2017).
- Organized guest lectures and community events as a member of the IIST Astronomy Club (2015-2016).
- Organizer, IIST Physics Club during the academic year 2015-2016.
- Coordinator (Science Lecture Organizing Team), Conscientia – 2014, the Annual Astronomy and Technology Festival of IIST.
- Coordinator, Dhanak – 2013, the Annual Cultural Festival of IIST.

REFERENCES

DR. ARVIND SINGH, Associate Professor

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