

# Anirudh Ravishankar

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## RESEARCH INTERESTS

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Galaxy evolution, hydrodynamical simulations, numerical models of clouds and gaseous haloes

## EDUCATION AND TRAINING

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### BS-MS Dual Degree

*Indian Institute of Science Education and Research (IISER), Tirupati, India* [ 20/08/2018 – 18/07/2023 ]

Field(s) of study: Physics

Final grade: 8.6/10

## RESEARCH EXPERIENCE

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### MS Thesis - Using radiative transfer codes and cosmological simulations to map cold gas emission

*Supervisors: Dr Gergö Popping (ESO), Dr Melanie Kaasinen (ESO), Dr Desika Narayanan (UFL)* [ 27/06/2022 – 31/08/2023 ]

ALMA/NOEMA have recently helped resolve molecular line emission from cold gas in galaxies at high redshift. To physically interpret existing and upcoming observations, I created synthetic maps of resolved sub-/millimetre line emission. To achieve this, I inferred the properties of molecular clouds in star-forming galaxies taken from the SIMBA simulation and performed radiative transfer modelling with Despotic. I made scripts on Python (packages: despotic, yt, caesar) to facilitate this and ran them as arrays of jobs on the **University of Florida HiPerGator (HPC) with SLURM**. I ran these jobs in the parallel-processing mode to solve for numerous gas particles simultaneously. With this, I significantly improved the semi-analytical modelling employed in the code SLICK (refer to GitHub). I found that the emission of CO rotational lines and the presence of H<sub>2</sub> gas varies radially in main-sequence galaxies, and that these variations could be driven by gas properties such as metallicity and temperature. This work will lead to a paper (Anirudh et al. in prep.) which is expected to be published by December 2023.

### Semester Project (Grade: 10/10) - Adiabatic invariance in Staechel potentials

*Supervisor: Dr Arunima Banerjee (IISER Tirupati, India)* [ 03/01/2022 – 15/05/2022 ]

Theoretical studies of stellar orbits have shown the importance of finding integrals of motion to understand the dynamics of expanding dark matter halos. To determine whether the action integrals in elliptical galaxies are invariant, I employed the Hamilton-Jacobi formalism and Action-Angle variables in ellipsoidal coordinates for Staechel triaxial potentials. I analytically proved the invariance of actions in all three dimensions for radial and circular orbits in a Staechel potential with an adiabatically increasing central density.

### Semester Project (Grade: 9/10) - Fragmentation in the Taurus B213 filament

*Supervisor: Dr Eswaraiah Chakali (IISER Tirupati, India)* [ 16/08/2021 – 24/12/2021 ]

Studies of low-mass star-forming regions have demonstrated the effect of thermal instability, magnetic fields, and turbulence on filament fragmentation. To test this observationally, I used 850-micron dust emission maps from the JCMT BISTRO Survey and dust temperature and column density maps from the Herschel Gould Belt Survey to identify dense, star-forming cores in the filament. I ran the FellWalker algorithm of the Starlink Project to obtain the clump properties and derived the Jeans length and Jeans mass of the filament. I concluded that the fragmentation of the B213 filament may have occurred due to thermal Jeans instability and sinusoidal perturbations in the presence of strong large-scale magnetic fields perpendicular to the filament. I further proposed that deviations from this model may be attributed to inhomogeneous accretion and the turbulent medium. This work has been published in a special issue titled "Star formation studies in the context of near-infrared (NIR) instruments on 3.6-m DOT" of the Journal of Astrophysics and Astronomy in 2023.

### 3rd ESO Summer Research Programme - "From birth to death: The multiple faces of accretion"

*Supervisors: Dr Carlo F. Manara (ESO), Dr Anna F. Pala (ESO), Dr Nicola Gentile Fusillo (ESO)* [ 05/07/2021 – 13/08/2021 ]

I was one of six students selected for the ESO Summer Research Programme 2021. I worked on characterising the variability of stars in the Solar neighbourhood. Using Gaia EDR3 photometric data, I selected candidate YSOs and Cataclysmic Variables (CVs) within a distance of 250 pc (about 10 million sources). I employed various cuts based on data quality and variability in ZTF/ASAS-SN archives and found 21 previously unidentified highly variable sources. I also extensively used TOPCAT and Python throughout this project. To compare this variability of unknown sources with known ones, I fitted VLT X-Shooter spectra of three known CVs and one known YSO using stellar atmospheric models (BT-Settl and Koester WD) and modified blackbody models.

Link: <https://www.eso.org/public/blog/2021-summer-research-students/>

## Introductory projects - Characterising the properties of young stellar objects

*Supervisor: Dr Jessy Jose (IISER Tirupati, India)*

I worked on several projects involving star formation and stellar astronomy. In my first introductory project to astrophysics, I used archival data from HST, Subaru HSC, and Spitzer along with BT-Settl atmospheric models to compute the mean age and mean mass of the central region of the OB association - Cygnus OB2. I also identified nebulous regions in the area using ds9 and HSC r2 band data.

In my second project, I used Gaia EDR3 data to obtain astrometric information on the open cluster - NGC 2244. I identified the cluster members using a 4-component, 5-parameter Gaussian Mixture Model, thus removing foreground and background sources. From the members, I found quantities such as the mean pmra, mean pmdec, mean parallax, the total proper motion, and the distance to the cluster.

## TECHNICAL SKILLS

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### Programming languages

Python (Libraries: NumPy, Scipy, matplotlib, pandas, **astropy**, **yt**, **caesar**, **aplpy**, **fsps**, **Despotic**, **PyCupid**, sklearn), bash, Fortran, C++, MySQL, ADQL

### Software, Tools, and Applications

SLURM HPC on HiPerGator (running job arrays, file transfer), LaTeX, Unix (embedded systems), TOPCAT, ds9, fv, Starlink, Git, vi, Linux, GIMP, Windows

### Astronomical archives

Gaia, Vizier, SIMBAD, ZTF, ASAN-SN, SDSS, MAST(HST), HGBS

## PUBLICATIONS

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### "Role of magnetic fields in the fragmentation of the Taurus B213 filament into Sun-type star-forming cores"

Anirudh, R., Eswaraiah, C., Jiao, S., & Jose, J. 2023, Journal of Astrophysics and Astronomy, 44, 59

## CONFERENCES AND SEMINARS

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### 7th Southern Regional Astronomy Meeting

[ IUCAA , MarThoma College, and Providence Women's College, India, 08/09/2021 – 10/09/2021 ]

I presented my ESO Summer Research Programme work at the UG/PG session of the 7th Southern Regional Astronomy Meeting, 2021. I also attended talks by numerous astronomers in the Cosmology, Stellar Astronomy, and the ISM & Galaxies sections.

### 3rd ESO Summer Research Programme

[ European Southern Observatory, Garching bei München, Germany, 05/07/2021 – 13/08/2021 ]

At the end of the Programme, I gave a presentation on my project to the entire ESO community. I also attended 10 Lectures as part of the Summer Research Programme about galaxy evolution, cosmology, telescope-making, stellar populations, planetary formation, AGN, etc. I interacted with several postdocs and senior astronomers working at ESO, which allowed me to have a glimpse of a variety of subfields in astronomy. During these six weeks, I also participated in weekly colloquia on different research topics. This memorable experience motivated me to pursue astrophysics as a career.

Link: <https://www.eso.org/sci/meetings/2021/SummerResearch2021/schedule.html>

### 38th Meeting of The Astronomical Society of India

[ Indian Institute of Science Education and Research, Tirupati, India, 13/02/2020 – 17/02/2020 ]

I attended a public talk titled "First EHT results: Black Hole shadow in M87" by Dr Eduardo Ros. Over the four days, I also participated in Extragalactic Astronomy, General Relativity, and Cosmology presentations by eminent astrophysicists in the country. This conference led me to try out my first projects in astronomy.

## FUNDED PARTICIPATION IN EVENTS

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I was awarded funding for my travel and stay in Munich for the six weeks of the ESO SRP. Due to the pandemic, the programme was conducted online, and I received a sizeable allowance to cover my expenses during this period.

I was funded by my institute to participate as a member of the basketball team at the Inter-IISER Sports Meet in 2018 and 2019. I was also a member of the band and performed at the Inter-IISER Cultural Meet in 2018.