NASSP Student Project Proposal

Project Information

Project Title: Study of bending waves in MHONGOOSE galaxies
Level of Project: Master's

Supervision

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Project Description

Bending of the disc is a common phenomenon that occurs in galaxies and is manifested as undulations in the vertical distribution of different components. Wrapping of the disc is a pronounced or visible result of disc bending that has been detected in both the Milky Way and numerous external galaxies through different tracers. In addition to such first-order perturbations, galactic discs also contain higher-order perturbations or bending modes, which are generally termed vertical corrugations [1, 2, 3, 5, 4, 6]. Due to their low bending amplitudes, such fluctuations are seldom detected in nearby disc galaxies, with most detections limited to edge-on galaxies. In addition, direct detection in density space in galaxies other than edge-on systems is challenging due to inclination effects. However, simulations show that the bending of a Milky Way–like disc galaxy is also associated with harmonic fluctuations in the measured line-of-sight velocities and can be regarded as a kinematic signature of a bending wave. In Nandakumar et al. (2022), we looked for similar signatures of bending waves in H I discs, as they extend far beyond the optical radii. A comprehensive multipole analysis of the H I column density and line-of-sight velocity fields of six nearby spiral galaxies from the THINGS sample uncovered signatures of bending in the H I discs [3]. We find that all of our sample discs show a combined kinematic signature consistent with the superposition of a few lower-order bending modes, suggesting that bending waves are a common phenomenon.

This project is a continuation of this work, where we will explore vertical corrugations in nearby galaxies in the southern sky for the first time using the unprecedented sensitivity of MeerKAT in H I observations. The project will primarily use selected galaxies from the MHONGOOSE survey, one of the large survey projects that provides extremely sensitive H

I observations of nearby galaxies. The project will also focus on studying the nature of H I vertical perturbations at the outer extent of galactic discs and investigate the effects of the surrounding environment in this process.

Upon successful completion of the project, the student will gain overall experience working on a radio astronomy research project. The student will become familiar with interpreting and appreciating the scientific insights derived from H I observations. In addition, the student will develop a deeper understanding of galactic dynamics, particularly vertical dynamics in relation to the atomic phase of the interstellar medium (ISM). This project also has strong potential for an impactful publication upon the successful detection of H I bending waves in several MHONGOOSE galaxies.

Skills Required

A background in astrophysics or related coursework is mandatory. The assigned student will be extensively using H I intensity maps from MeerKAT observations; therefore, basic knowledge of radio interferometry and the 21 cm line emission is preferred. A decent knowledge of Python is also mandatory, as the student will use several Python-based codes during the analysis. Familiarity with astronomical software such as CARTA will be an advantage.

References

[1] A. M. Fridman, O. V. Khoruzhii, E. V. Polyachenko, A. V. Zasov, O. K. Sil'chenko, A. V. Moiseev, A. N. Burlak, V. L. Afanasiev, S. N. Dodonov, and J. H. Knapen. Gas motions in the plane of the spiral galaxy NGC 3631. , 323(3):651–662, May 2001.

[2] A. M. Fridman, O. V. Koruzhii, A. V. Zasov, O. K. Sil'chenko, A. V. Moiseev, A. N. Burlak, V. L. Afanas'ev, S. N. Dodonov, and J. Knapen. Vertical motions in the gaseous disk of the spiral galaxy NGC 3631. *Astronomy Letters*, 24(6):764–773, November 1998.

[3] Meera Nandakumar, Chaitra Narayan, and Prasun Dutta. Bending waves in velocity space: a first look at the THINGS sample. , 513(2):3065–3075, June 2022.

[4] Chaitra A. Narayan, Ralf-Jürgen Dettmar, and Kanak Saha. Wobbly discs - corrugations seen in the dust lanes of edge-on galaxies. , 495(4):3705–3714, July 2020.

[5] M. C. Sánchez Gil, E. J. Alfaro, and E. Pérez. Corrugated velocity pattern in spiral galaxies: NGC 278, NGC 1058, NGC 2500 and UGC 3574. In *Highlights of Spanish Astrophysics VI*, pages 401–401, November 2011.

[6] M. Carmen Sánchez-Gil, Emilio J. Alfaro, and Enrique Pérez. Corrugated velocity patterns in the spiral galaxies: NGC 278, NGC 1058, NGC 2500 & UGC 3574. , 454(4):3376–3390, Dec 2015.