6th URSI Regional Conference on Radio Science (URSI - RCRS 2024)

Stereoscopy in Distant Galaxies: Techniques and Simulation

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Can we view a 3D image of a galaxy?

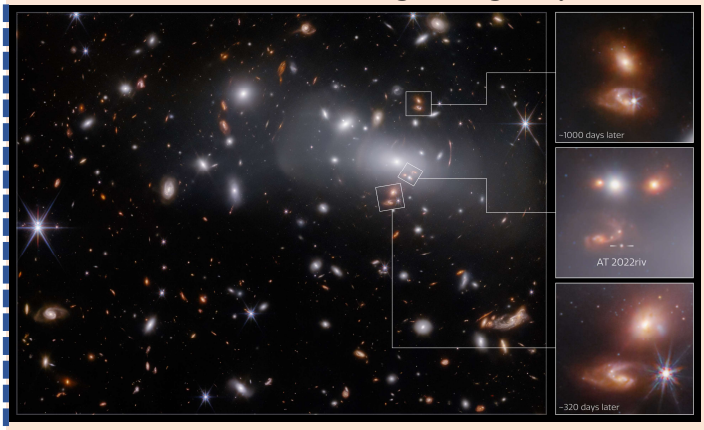

Fig1. James Webb Space Telescope (JWST), (Kelly, 2023).

In stereoscopic astronomy, the concept of the stereo base is critical for achieving depth perception when observing distant celestial objects. When multiple telescopes, positioned at different locations on Earth or in space, observe the same galaxy, the distance between them effectively serves as the stereo base. By analyzing the disparity between two images of the same celestial object, captured from slightly different perspectives, we can reconstruct the depth and spatial relationships within these distant systems.

VIEW STEREOSCOPY

View Stereoscopy leverages multi-angle imaging to create a three-dimensional representation of galaxies. This technique is particularly useful in weak gravitational lensed studies, where the shapes of distant galaxies are (albeit distorted) due to the gravitational influence of foreground mass distributions.

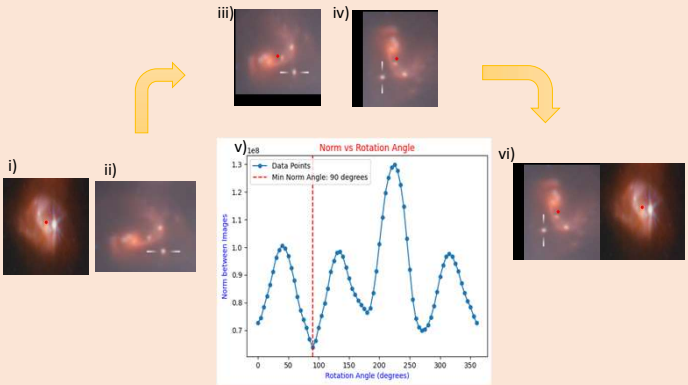

Fig 2. Process showing modification of Galaxy A2 such that galaxies A1 and A2 have minimum norm (denoted by red vertical line in the graph) and act as stereo pairs.

ART ALGORITHM

Algebraic Reconstruction Techniques (ART) were introduced by Gordon, et al.(Gordon et al., 1970; Jaman et al., 1985b) for solving the problem of three-dimensional reconstruction from projections in electron microscopy and radiology. ART is an iterative procedure which starts with an initial estimate of the image and then update the pixel values so that they satisfy the given projection data.

REFERENCES:

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4. Sohn, S.T., Watkins, L.L., Fardal, M.A., van der Marel, R.P., Deason, A.J., Besla, G., Bellini, A. 2018. Absolute Hubble Space Telescope proper motion (HSTPROMO) of distant Milky Way globular clusters: Galactocentric space velocities and the Milky Way mass. *The Astrophysical Journal*, **862**(1), 52.

We implemented this technique by modeling a galaxy with a logarithmic spiral structure and viewing it from three distinct angles (0°, 45°, and 90°).

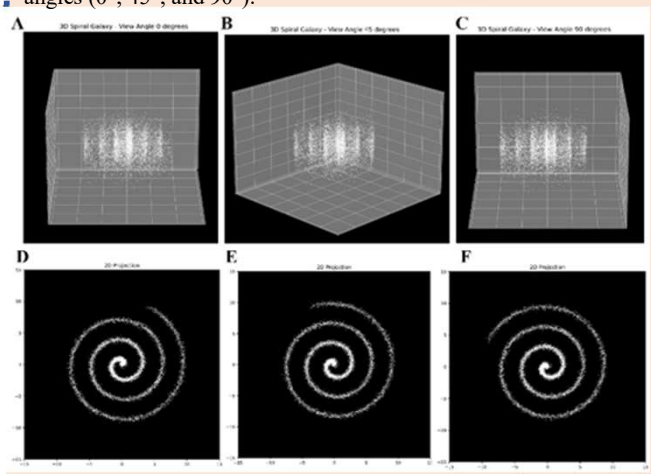

Fig.3 Images from A) to C) are the 3D view of galaxy at angles 0,45 & 90. These views when projected on a 2D planes form corresponding images D), E) and F).

This is a deconvolution problem of a particular type: an estimate of a function in a higher dimensional space is deconvolved from its experimentally measured projections to a lower dimensional space.

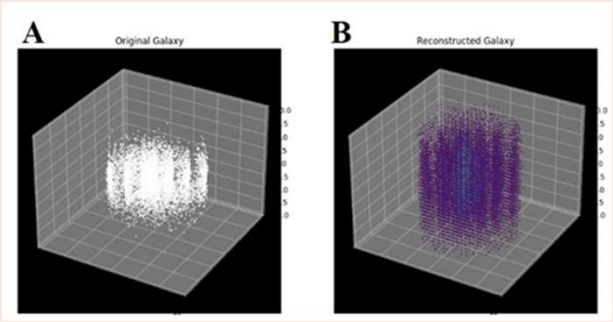

Fig. 4 Inset shows A) and B) images show the original and image reconstructed using ART algorithm respectively.

GALACTOCENTRIC VELOCITY APPROACH

Stereoscopy Using Galactocentric Velocities focuses on the kinematic properties of galaxies, providing insights into their internal dynamics and interactions. This approach involves acquiring 6D phase space information of galactic clusters and extrapolating their positions to generate a stereoscopic pair.

FUTURE WITH SOLAR GRAVITATIONAL LENSING

An SGL probe or more feasibly, a fleet of such probes would need to scan and sample the distant galaxy's extensive region systematically, pixel by pixel. This process involves measuring the brightness of the Einstein ring at various locations to construct a resolved image of the original distant source. The angular resolution of the SGL is, in principle, a few times 10^{-10} arcsec at the focal region. The challenges of this technique lie in the immense spatial scale and the need for precise measurements to reconstruct detailed images from the amplified light.

CONCLUSIONS

Our findings indicate that given current temporal and resolution constraints, both time and view stereoscopy offer limited utility. However, the integration of multiple images presents a viable opportunity to enhance image quality through the ART algorithm.

ACKNOWLEDGEMENTS:

IR is thankful to Indian Institute of Technology Madras, India for a congenial environment for thoughtful thinking and her encouraging academic Professors.