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How to stir galactic disks ?

Two CNRS researchers at the Strasbourg Observatory have shown that in spiral galaxies containing a central bar - an elongated structure composed of stars - a vigorous mixing of stars in the disk takes place. They presented their work this week at the meeting of the American Astronomical Society. Until now, astronomers have attributed this mixing process, named "radial migration," solely to spiral structure, while ignoring the effects of the bar. Astronomers Ivan Minchev and Benoit Famaey have shown that in barred spiral galaxies, such as our own Milky Way, radial migration occurs much faster and in a different fashion than previously thought. In this process, stars in the disk are displaced by thousands of light-years from their birth radii while preserving their circular orbits. This new study indicates that our Sun could have experienced a similar fate: its path also traces a circular orbit while its chemical composition corresponds to that of a star ten thousand light-years closer to the galactic center.

This stirring of the disk results from chaotic regions caused by the proximity of the bar and spiral resonances. A common example of a resonance is when a person pushes a playground swing precisely in time with the frequency of the swing, which makes the swing go higher and higher. At certain radii in galaxies, resonances occur between the frequency of the radial oscillations of stars and the rotation frequency of the bar and spiral. The ratio of the rotation frequencies of the bar and spiral determines the proximity of the resonance radii, and thus the strength of radial migration.

The results of this study could help explain why there is such a large variation in the chemical composition of stars near the Sun. In addition, observations of spiral galaxies other than the Milky Way show that the presence of a central bar produces a more even chemical composition throughout the disk than galaxies which lack bars. This study suggests that the powerful mixing of stars in the disk in the case of barred galaxies blurs an otherwise steep chemical gradient, thus providing a theoretical explanation for these observations.

A thorough knowledge of the interaction between the bar and the spiral is crucial for understanding the way the chemical composition of the Galaxy evolves with time. When modeling the Milky Way or any other galaxy with a bar and a spiral pattern, one can thus no longer consider the phenomena linked to the presence of the bar and of the spiral separately. Instead, simulations must synthesize these features to make progress in our understanding of galaxy evolution.

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