BAR-DRIVEN SPIRAL DENSITY WAVES AND ACCRETION OF GAS-DOMINATED CENTRAL DISKS

CHI YUAN
Institute of Astronomy and Astrophysics, Academia Sinica
Box 1-87, Nankang, Taipei, Taiwan, ROC
e-mail: yuan@biaa7.biaa.sinica.edu.tw

1. Introduction

In this short paper, we report the main results of a comprehensive theory of bar-driven spiral density waves. The theory offers explanations of the morphological difference of the spirals observed in the gas-dominated central disks as well as the different patterns of isovelocity curves distorted by the waves. It also gives reliable estimates of the induced mass flux to fuel the AGNs and starburst ring activities and hence the lifespan of the central disks. In particular, we compare our results with the CO and HCN observations of NGC1068 and M100. Based on these results, we can speculate the possible origin of the central bars and will propose two critical observational tests of the theory.

2. Theoretical Results

We summarize our results (Yuan and Kuo 1997) as follows:

(1) Three Morphological Types of Spirals: For the outer Lindblad resonance (OLR), the spirals are tight and trailing. For the outer inner Lindblad resonance (OILR), spirals are relatively open and trailing. For the inner inner Lindblad resonance (IILR), spirals are relatively open and leading.

(2) Patterns of Isovelocity Curves: Independent of orientation and inclination, the isovelocity curves for spiral waves excited at the OLR are always bent inward along the spiral arms and those at the OILR and IILR are always bent outward along the spiral arms.

(3) Angular Momentum Transport: The torque exerted on the disk

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by the bar will cause the disk material to move outward (inward) for the case of OLR (ILR's). This will either lead to starburst ring activities (OLR) or fueling the AGNs (ILR's). The mass flux, inward or outward, in this mechanism is typically of 1 solar mass per year. This implies that the life span of the disk is of the order of 10^9 years. It in turn suggests that AGNs and starburst ring activities are relatively short-time and possibly recurrent phenomena, unless the mass of the central disk can be continuously replenished from the central bulge.

3. Comparison with Observations

Results are compared with the observations of NGC1068 (Planesas, Scoville and Myers 1991; Helfer and Blitz 1995) and M100 (Sakamoto et al. 1995). We choose them because we beieve NGC1068 has a fast bar and M100 has a slow bar, therefore the former should have tightly wound spirals with inward-bent isovelocity curves along them while the latter, open spirals with outward-bent isovelocity curves. These features are in good agreement with the observations (Yuan and Kuo 1997a).

4. Conclusion

We have linked the phenomena associated with the central disks in two sequences which can be tested by observations, namely:

Tight Spirals ↔ Fast Bar ↔ Inward-bent isovelocity Curves

Open Spirals ↔ Slow Bar ↔ Outward-bent isovelocity Curves

We can speculate that a fast bar may arise from Jacobi type of instability at the center. This requires high concentration of matter there. Galaxies with such a concentration of mass is characterized by a rapidly rising rotation curve. We can also speculate that a slow bar may results from an "orbit trapping" at the ILR. This requires that $\Omega_p = \Omega - \kappa/2$, has a maximum, or a slowly rising rotation curve. This may be tested by observing:

Rapidly Rising Rotation Curve ↔ Tight Spirals

Slowly Rising Rotation Curve ↔ Open spirals.

So far there three galaxies follow this rule, namely, NGC1068, M100 and the Milky Way. We hope to expand our list with future observations.

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