Predicted kinematics of NGC 3124

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The galaxy NGC 3124 remarkably has two spiral arms in the bar which open in the opposite sense to the spiral arms of the disk.
The question naturally arises: "Are the bar's spiral arms trailing or leading?".

Photo credit: Oliver Tunnah / The Faulkes Telescope Project / LCOGT.net

The directions of orbits and of pattern rotations are stated here relative to the photograph above [1].

The bar arms were first noticed in photographs by [2], and have been examined by other researchers, see [3] and [4].

In this paper three models are proposed and compared:.
1. A conventional model which simply assumes that the bar orbits are in the same direction as the disk orbits.
2. A conventional model which assumes that the bar orbits are in the opposite direction to the disk orbits.
3. A new model which is based on a new theory of elongated bars [6].

The three models differ in their kinematics of the bar, but all three models share the same kinematics of the disk.

Kinematics of the disk (all three models)

The disk orbits are anti-clockwise.
The disk pattern rotation is anti-clockwise.
The disk spiral arms are trailing.

Kinematics of the bar

1. Conventional model
The bar orbits are anti-clockwise.
The bar pattern rotation is anti-clockwise.
The bar spiral arms are leading.

2. Conventional model with orbital counter-rotation
The bar orbits are clockwise.
The bar pattern rotation is clockwise.
The bar spiral arms are trailing.

3. New model
The bar orbits are clockwise.
The bar pattern rotation is anti-clockwise.
The bar spiral arms are trailing relative to the bar orbits.
The bar spiral arms are leading relative to the bar pattern rotation.

Discussion

The Hα velocity data [5] indicates that the orbits are all anti-clockwise in the photograph [1]. If that data represents a complete picture of the directions of all the orbits, it would indicate that model 1 is correct.

However, the hypothetical possibility is considered here, that future spectroscopy, of lines other than Hα, may reveal that the bar region additionally has orbits in the clockwise direction in the photograph. If hypothetically that happens, then it may indicate the possibility that model 2, or model 3, is correct.

Based on [6], the author considers that model 3 is the most likely to be correct.

Next the possibility of dynamical coupling (defined here as: bar and disk have pattern rotations identical in direction and rate) is examined. In model 2, the pattern rotations of bar and disk are in opposite directions, so dynamical coupling of the bar and the disk is impossible.

In model 3 the pattern rotations of the bar and disk are in the same direction, so dynamical coupling of the bar and the disk is possible. Based on (a) the positions of the inner extremities of the two main arms of the disk, relative to the size and orientation of the bar outline, (b) comparision with those positions in other galaxies, (c) other considerations, it is likely that the bar and disk are indeed coupled.

Conclusion

Based on a new theory of the direction of precession of x1 orbits in elongated bars as defined in [6], it is predicted that in the included photograph of NGC 3124 [1]:

The disk orbits are anti-clockwise.
The disk pattern rotation is anti-clockwise.
The disk spiral arms are trailing.
The bar orbits are clockwise.
The bar pattern rotation is anti-clockwise.
The bar spiral arms are trailing relative to the bar orbits.
The bar spiral arms are leading relative to the bar pattern rotation.
The bar and the disk are likely to be dynamically coupled (share the same rate and direction of pattern rotation).

References

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Version 1: 15 September 2013.
Version 2: 29 December 2013: added photograph