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GEOMETRIC OFFSETS ACROSS SPIRAL ARMS IN M51: NATURE OF GAS AND STAR FORMATION TRACERS

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ABSTRACT

We report measurements of geometric offsets between gas spiral arms and associated star-forming regions in the grand-design spiral galaxy M51. These offsets are a suggested measure of the star formation timescale after the compression of gas at spiral arm entry. A surprising discrepancy, by an order of magnitude, has been reported in recent offset measurements in nearby spiral galaxies. Measurements using CO and Hα emission find large and ordered offsets in M51. On the contrary, small or non-ordered offsets have been found using the H I 21 cm and 24 μm emissions, possible evidence against gas flow through spiral arms, and thus against the conventional density-wave theory with a stationary spiral pattern. The goal of this paper is to understand the cause of this discrepancy. We investigate potential causes by repeating those previous measurements using equivalent data, methods, and parameters. We find offsets consistent with the previous measurements and conclude that the difference of gas tracers, i.e., H I versus CO, is the primary cause. The H I emission is contaminated significantly by the gas photodissociated by recently formed stars and does not necessarily trace the compressed gas, the precursor of star formation. The H I gas and star-forming regions coincide spatially and tend to show small offsets. We find mostly positive offsets with substantial scatter between CO and Hα, suggesting that gas flow through spiral arms (i.e., density wave) though the spiral pattern may not necessarily be stationary.