EXTENDING THE SEARCH FOR COUNTERROTATING GAS AND STARS IN GALAXIES: A STUDY OF LATE-TYPE DWARFS

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In a previous study on gas-stellar counterrotation for a large sample of E/S0 and spiral galaxies (Kannappan & Fabricant 2001), two dwarf irregular galaxies were included, of which one was tentatively identified as a counterrotator. Here we extend the search for counterrotation to include 10 more irregular/spiral dwarf galaxies. We find that all systems with well defined gas and stellar rotation show kinematics consistent with co-rotation. However, we see evidence of decoupled gas and stellar kinematics in \( \gtrsim 50\% \) of the sample, possibly reflecting minor interactions too small to create large-scale gas-stellar counterrotation.

Except for one dwarf Im, all of the gas-stellar counterrotators found by Kannappan & Fabricant (2001) were low-luminosity E/S0 systems (Fig. 1). This morphological tendency is consistent with a scenario in which retrograde mergers and interactions between galaxies produce counterrotating gas and stars, because such events also reshape galaxies into more concentrated/centrally bulging E/S0 types. However, no conclusions on counterrotation frequency could be reached for low-luminosity galaxies with irregular/spiral morphologies, due to limited stellar kinematic data.

Kannappan & Fabricant’s tentative identification of a dwarf irregular counterrotator suggests that luminosity instead of morphology could be the primary correlate with counterrotation, perhaps supporting a scenario in which retrograde gas arrives via efficient “cold-mode” gas accretion, which occurs mainly in low mass galaxies (Birnboim & Dekel 2003). To test these scenarios, we present new stellar kinematic data for 10 late-type dwarf/irregular galaxies, obtained with the FAST spectrograph on the 60” telescope at Mt. Hopkins, Arizona. Our sample consists of galaxies with B-band effective surface brightnesses between 20.8 and 23.6 (somewhat high for dwarfs). Of these, seven are type Sdm-Im and three are type Pec. Our galaxies reside in global environments ranging from below the mean density of the field, up to nearly the density of the Virgo Cluster, with a median of \( \sim 2 \times \) the mean field density (as estimated using code from Grogin & Geller 1998). We measure gas and stellar kinematics using emission and absorption lines (Fig. 2) in the 4000–6000 Å range. The gas rotation curves are extracted by simultaneous fitting of the H\( \beta \) and nearby [OIII] emission lines. The stellar rotation curves are obtained by cross correlating with stellar templates spanning a range of metallicities. We homogenize velocity zero points between templates by adopting corrections (0-24 km/s) chosen to minimize gas-stellar velocity differences for the majority of galaxies.

All sample galaxies with well defined gas and stellar rotation show kinematics consistent with co-rotation. If the cause of counterrotation is luminosity dependent (efficient gas accretion in low-mass galaxies), then the low frequency of counterrotators in this sample is mildly surprising, but the sample is small. Also, retrograde gas may not survive in such gas-rich systems. If the cause of counterrotation is
morphology dependent (mergers/interactions) then these results are as expected.

Despite the lack of counterrotation, we do see evidence of kinematically decoupled gas and stars in at least five of the late-type dwarfs. The high frequency (\( \geq 50\% \)) of gas-stellar decoupling in our sample could reflect minor interactions too small to create large-scale gas-stellar counterrotation. Of the five galaxies with clear gas-stellar decoupling, three (UGC9562, UGC7690 and NGC3846) have close companions of either comparable or fainter magnitude, all within 70 kpc.\(^5\) The other two galaxies with gas-stellar decoupling (IC2520 and UGC8630) seem to be merger remnants, one showing merging kinematic sub-components. We note that gas-stellar velocity differences may also be produced by energetic internal disturbances (e.g. supernovae) or by cold-mode accretion arriving in dynamically significant discrete clumps.

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\(^5\)The two Im galaxies UGC7950 and UGC7009 also have companions within 100 kpc, one brighter and one fainter.