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GASP XXIX – unwinding the arms of spiral galaxies via ram-pressure stripping

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ABSTRACT

We present the first study of the effect of ram pressure 'unwinding' the spiral arms of cluster galaxies. We study 11 ram-pressure stripped galaxies from GASP (GAs Stripping Phenomena in galaxies) in which, in addition to more commonly observed 'jellyfish' features, dislodged material also appears to retain the original structure of the spiral arms. Gravitational influence from neighbours is ruled out and we compare the sample with a control group of undisturbed spiral galaxies and simulated stripped galaxies. We first confirm the unwinding nature, finding that the spiral arm pitch angle increases radially in 10 stripped galaxies and also simulated face-on and edge-on stripped galaxies. We find only younger stars in the unwound component, while older stars in the disc remain undisturbed. We compare the morphology and kinematics with simulated ram-pressure stripping galaxies, taking into account the estimated inclination with respect to the intracluster medium (ICM) and find that in edge-on stripping, unwinding can occur due to differential ram pressure caused by the disc rotation, causing stripped material to slow and 'pile up'. In face-on cases, gas removed from the outer edges falls to higher orbits, appearing to 'unwind'. The pattern is fairly short-lived ($<$0.5 Gyr) in the stripping process, occurring during first infall and eventually washed out by the ICM wind into the tail of the jellyfish galaxy. By comparing simulations with the observed sample, we find that a combination of face-on and edge-on 'unwinding' effects is likely to be occurring in our galaxies as they experience stripping with different inclinations with respect to the ICM.

Key words: galaxies: interactions – galaxies: kinematics and dynamics – galaxies: evolution – galaxies: clusters: general – galaxies: ISM – galaxies: clusters: intracluster medium.

1 INTRODUCTION

The development and evolution of galaxies is heavily influenced by gas inflows and outflows, since gas is the fuel of star formation in galaxies. Understanding how gas behaves both within the disc and in the surroundings of a galaxy is therefore vital in building a complete picture of its evolution. Galaxies can experience changes in their gas content in isolation, due to internal effects such as winds from, e.g. Wolf–Rayet and OB-type stars, supernova feedback, and feedback from active galactic nucleus (AGN) activity (Veilleux, Cecil & Bland-Hawthorn 2005; Ho et al. 2014). External environmental forces can also influence and, in some cases, dramatically alter the gas content within a galaxy (Boselli & Gavazzi 2006). Within galaxy clusters, the largest gravitationally bound objects in the Universe, there are many environmental processes that can affect individual galaxies owing to the increased frequency of interactions with other galaxies, and also to interaction with the dense intracluster medium (ICM). As galaxies move through a cluster, they may experience gravitational and hydrodynamical effects. Gravitational effects, such as tidal interactions with the cluster (Byrd & Valtonen 1990; Valluri 1993) and gravitational interactions between galaxies (Spitzer & Baade 1951; Toomre 1977; Tinsley & Larson 1979; Merritt 1983; Mihos, Bothun & Richstone 1993; Springel 2000), affect both the stellar and gas components of a galaxy. Hydrodynamical effects resulting from the cluster ICM affect only the gas content of the galaxy, as the stars are too massive and compact to be susceptible to hydrodynamical influence.

One particular hydrodynamical effect that plays a key role in transforming and quenching galaxies in clusters is ram-pressure

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