A Westerbork blind HI imaging survey of the Perseus-Pisces filament in the Zone of Avoidance

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Abstract

In this thesis we study a structure associated with the Perseus-Pisces Supercluster (PPS; cz $\sim$ 6000 km s^{-1}), where it crosses the Zone of Avoidance (ZoA) at the Galactic longitude of $\ell \approx 160°$. This largely unexplored region contains the X-ray emitting 3C 129 cluster which hosts two strong radio sources with bent morphologies, thus indicative of a rich intra-cluster medium (ICM). Due to its low Galactic latitude of $b = 0.27$, where Galactic extinction is severe at optical wavelengths ($A_B = 1.8 - 8.0$), the details of its galaxy population and dynamics had not been investigated in detail before. Additionally, the diverse and dynamic cosmic environments of the PPS with the embedded galaxy cluster make this region an ideal laboratory to study the effects on these environments on the galaxy properties and galaxy transformation processes therein.

We used the Westerbork Synthesis Radio Telescope (WSRT) to blindly map this ZoA crossing of the PPS in the 21 cm H I-wavelength. This was conducted through 35 individual pointings observed for a total of 420 hours, covering a large area of about 9.6 sq.deg and a velocity range of approximately $cz \sim 2000-16000$ km s^{-1}, thus mapping the immediate surrounding regions to enable investigations of the various cosmic environmental effects on the H I properties of galaxies. With the resulting spectral line data cubes of an angular resolution of $23'' \times 16''$ and a velocity resolution of 16.5 km s^{-1} with a rms sensitivity of $\sim$ 0.4 mJy/beam, we detect 211 galaxies within the entire surveyed volume.

These new H I detections reveal a total of four distinct overdensities. Of these overdensities, the two major ones are located at the distance of the PPS at $cz \sim 4000 - 8000$ km s^{-1} and behind it at $cz \sim 8000 - 12000$ km s^{-1}. The galaxy overdensity associated with the PPS is used to demonstrate how this

supercluster connects across the ZoA and confirms earlier indications of a filamentary connection between Perseus, Pisces and the A569 clusters through this region of the sky. Galaxies in the background of the PPS seem to be part of the CID15 structure that had been earlier predicted in the reconstructed density and velocity maps from the 2MASS Redshift Survey.

We carry out a detailed census of the galaxy population in the 3C 129 cluster by combining the H I-data of the gas-rich galaxies with the near-infrared (NIR) images of the gas-poor galaxies. The NIR galaxies are identified from the high resolution ($0.2''$/pix, seeing $\sim 0.8''$) images of the UKIDSS Galactic Plane Survey. We obtain photometry in the J, H and K bands for about 9700 galaxies identified in the NIR images within the WSRT H I surveyed area. These measurements are used to derive the red-sequence of this cluster through the $(J-K)$ vs K colour-magnitude diagram to identify the gas-poor cluster member candidates. Within the spatial extent of the cluster of radius ~ 1.7 Mpc, a total of 261 galaxies are identified as cluster members, with 23 detected in H I. An assessment of the morphologies of these galaxy members reveals a clear morphological segregation, with E and E/S0 galaxies dominating the inner regions of the 3C 129 cluster and the late-type spirals found in the cluster outskirts.

We also examine the richness of the cluster by comparing it to two well-known clusters at similar redshifts. One being a massive cluster in the Great Attractor region, namely the Norma cluster, also located in the ZoA but in the South, and the other being the Coma cluster. The comparison shows that the 3C 129 cluster is quite rich as was suspected. The galaxy density in the core of the 3C 129 cluster is similar to that in the Norma cluster and slightly less than in the Coma cluster. Furthermore, an assessment of the spatial distribution of galaxies in the core shows a slight asymmetry aligned with the irregular distribution of the X-ray emission, thus consistent with the results from the X-ray analysis which surmised that the 3C 129 cluster seems to have undergone a merger and has not yet reached a dynamically relaxed state. In support of this we find a large substructure dominated by gas-rich galaxies North of the main cluster at a slightly higher recession velocity which could be falling into the cluster. All these findings seem to support a scenario where the 3C 129 cluster is still growing through accretion of galaxies from the PPS filament.

The wealth of H I data allows an analysis of the environmental effects on the galaxy properties within the WSRT surveyed volume. We first characterise the cosmic environments found within the two major overdensities as outlined by the H I-detected galaxies. This is conducted by perfoming tests to search for substructures. A total of four distinct substructures are found within the PPS ZoA overdensity ($cz \sim 4000 - 8000$ km s^{-1}) and three in the back-

ground galaxy overdensity ($cz \sim 8000 - 12000$ km s^{-1}). Our analysis of the H I properties of galaxies in these varying cosmic environments shows that highly disturbed H I-disks are found in larger and tightly bound groups, due to the higher incidence of tidal interactions between the galaxies. Furthermore, an indication of H I-gas deficiency is found in the core of the 3C 129 cluster. We assess the cause of this deficiency through models of the ICM of the 3C 129 cluster and find ram-pressure stripping to be the dominant gas removal process in this region. Additionally, highly H I-gas deficient galaxies are also found in the cluster outskirts. Most of these galaxies are located within galaxy groups where galaxy-galaxy interactions and mergers are prevalent, thus highlighting the importance of these processes in removing gas from galaxies in groups.

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