INTRA-GROUP LIGHT IN HICKSON COMPACT GROUPS -
A WAVELET APPROACH

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Abstract. A diffuse component of intra-group light can be observed in compact groups of galaxies. This component is presumably due to stellar material tidally stripped from the member galaxies of the group, which gets trapped in the group potential. It represents an efficient tool for the determination of the stage of dynamical evolution of such structures and for mapping the gravitational potential of the group. Detecting this kind of low surface brightness structure (about 1% above the sky level) is a difficult task, which is subject to many problems like the modeling of stars and galaxy and sky subtraction. To overcome these problems, we apply a new method, the wavelet technique OV_WAV, with which these low surface brightness structures can be revealed and analyzed by separating different components according to their spatial characteristic sizes (allowing the study of the point sources, galaxies and diffuse envelope separately). We have analyzed 3 of the of the Hickson Compact Groups Catalogue (HCG 79, HCG 88 and HCG 95) and were able to detect this diffuse component in two of the studied groups: HCG 79, where the diffuse light corresponds to 46 ± 11% of the total B band luminosity and HCG 95, where the fraction is 11 ± 26%. HCG 88 had no component detected, as expected by its estimated early evolutionary stage.

1 Introduction

A simple visual inspection of the compact groups of galaxies in Hickson’s catalogue reveal that many of them are embedded in a diffuse intra-group light (IGL) component. This component is a useful test to measure the intensity of the tidal interactions suffered by the galaxies and may represent a direct way to map the extension and shape of the groups gravitational potential and the dark matter halo.

The study of the IGL structures is difficult and complex. With a very low surface brightness, in general 1 or 2% above the sky brightness level, those structures are often dimmed by the group member galaxies. The analysis process is very sensitive to the sky level estimate and modeling and subtraction of the galaxies and foreground stars in the field. To avoid this kind of effect we developed a new method to isolate the IGL contribution using the “à trous” wavelet transform, the package OV_WAV. The process detects different characteristic size structures, separating the types of light source in the image and identifying and measuring the IGL.

2 Method

The image analysis was performed with OV_WAV. The images are decomposed in wavelet coefficients using the “à trous” transform which separates the structures in each scale n with characteristic size, 2^n pixels. The detection, identification and reconstruction of objects are performed using a Multi-Scale Vision Model.

With OV_WAV there is no need of “a priori” information about the sky brightness level and the modeling of bright objects and it is an optimized method for detection of low surface brightness structures.

3 Observational Data, Analysis and Results

We have studied a sample of 3 Hickson compact groups (HCG 79, HCG 88 and HCG 95) as a pilot study for a larger survey to search for IGL. The groups were chosen for being in different evolutionary stages. Deep B and R images, obtained at the CFHT, were used in this analysis.

The detection and analysis of the IGL component of each group was performed with OV_WAV and simulated images were also analyzed in order to determine OV_WAV configuration parameters and estimate detection limits and systematic errors. The simulations showed that we are able to detect low-surface brightness extended structures, down to a S/N = 0.1 per pixel, which corresponds to a 5-σ-detection level in wavelet space.

Irregular IGL components were detected in 2 groups (HCG 79 and HCG 95) and no component was detected in HCG 88 up to the detection limit (29.1 mag arcsec^{-2}). The detected IGL components are shown in figure and the main properties are summarized in table.
Table 1: Properties of the IGL component detected in our sample.

| Group   | % (B and R) | <μ> (B and R) | Mag. (B and R) | (B - R)_0 |
|---------|-------------|---------------|---------------|-----------|
| HCG 79  | 46 ± 11%    | 24.8 ± 0.16   | 14.0 ± 0.16   | 0.86 ± 0.22 |
| HCG 95  | 11 ± 26%    | 27.3 ± 0.30   | 16.9 ± 0.30   | 1.75 ± 0.34 |

Figure 1: The left panel shows the B band image of HCG 79 with IGL in contour curves superposed, ranging from 24.2 to 25.1 magnitudes in steps of 0.1 B mag arcsec^{-2}. The right panel shows the B band image of HCG 95 with IGL in contour curves superposed, ranging from 26.9 to 27.8 magnitudes in steps of 0.1 B mag arcsec^{-2}.

4 Conclusions and Perspectives

We have detected an IGL component in HCG 79 and HCG 95, groups that present clear signs of galaxy interaction, indicating a compact and bound configuration for a few crossing times. HCG 79 presents an irregular IGL distribution, coherent with the X-Ray distribution, following the group potential, as well as the hot gas H and this component is bluer than the galaxies ((B-R) = 1.5), because it may be a mix of two different sources: stripped material from only the outer parts of the galaxies and the destruction of relatively blue dwarf galaxies. HCG 95 has an almost spherical IGL distribution around the interacting system HCG 95A/C, with colors that are coherent with the galaxies' red colors indicating an old stellar population. The absence of an IGL component in HCG 88 indicates an early stage of dynamical evolution, as expected by other group properties like the absence of strong signs of galaxy interaction.

Therefore, we can envision an evolutionary sequence for our sample, with HCG 79 being the most evolved group and in an advanced stage of dynamical evolution, with HCG 95 being in an intermediate stage and HCG 88 in an initial epoch still without an IGL components.

The presence of an IGL component indicates gravitationally bound configurations in which tidal encounters already stripped a considerable fraction of mass from the member galaxies and an advanced stage of dynamical evolution, providing tests for formation and evolution models of groups.

We are now conducting a survey to search for IGL in more HCG. We then will compare the measured light fractions and shapes to predictions from N-Body simulations in order to assess the dynamical age of those dense structures. We have already obtained data with the Laïca Wide Field Camera at Calar Alto (Spain), currently being processed, and were awarded time at the Wide Field Camera of INT (La Palma) in November 2005.

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