Radial Gradients in Elliptical Galaxies

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Abstract

The aim of this Thesis is to provide a contribution to the decades-long debate regarding the formation and evolution of early-type galaxies. Our approach to this open problem is to investigate the combined kinematic, photometric, and stellar population properties at large galactocentric radii for a sample of early-type galaxies. The galactocentric radial distribution of these properties is a chemodynamical imprint of the many physical mechanisms acting in galaxies, and provides us with strong constraints on competing galaxy formation scenarios.

Initially we the derive the star formation and chemical enrichment history of two massive early-type galaxies. Our analysis is based on new high signal-to-noise long-slit spectroscopic data obtained from the ESO 3.6m telescope, and high-resolution multi-band imaging data from the Hubble Space Telescope and wide-field imaging from the Subaru telescope. We derive stellar population radial profiles of age, metallicity [Z/H], and α-element abundance ratio [α/Fe] out to more than one effective radius, together with surface brightness profiles and isophotal shape parameters. The results suggest that the galaxies formed over half of their mass in a single short-lived burst of star formation at high redshift and evolved quiescently afterwards. This event likely involved an outside-in mechanism with supernova-driven galactic winds playing a fundamental role in shaping the observed steep negative radial metallicity gradients.

A similar study is performed out to $\sim 1-3$ effective radii for a sample of 14 low-luminosity, low-mass early-type galaxies in the Fornax and Virgo clusters. We use new high-quality long-slit spectroscopic data obtained from the Gemini telescope and multi-band imaging data from the Hubble Space Telescope. A gradual gas dissipation is suggested to be responsible for the old and extended stellar discs present in these galaxies. We extend our study to higher galaxy mass via a novel literature compilation of 37 early-type galaxies, which provides stellar population properties out to one effective radius. We find that metallicity gradients correlate with galactic mass, and the relationship shows a sharp change in slope at a dynamical mass of $\sim 3.5 \times 10^{10} \mathrm{M}_{\odot}$.

We conclude that low-luminosity, low-mass galaxies likely formed in an early star-forming collapse with extended, low efficiency star formation, and mass-dependent galactic outflows of metal-enriched gas. Luminous, high-mass galaxies might have formed initially by mergers of gas-rich disc galaxies and then subsequently evolved via dry merger events.

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Statement of originality

The work presented in this thesis has been carried out in the Centre for Astrophysics & Supercomputing at the Swinburne University of Technology between 2006 and 2009. This thesis contains no material that has been accepted for the award of any other degree or diploma. To the best of my knowledge, this thesis contains no material previously published or written by another author, except where due reference is made in the text of the thesis. The content of the Chapters listed below has appeared in refereed journals. Minor alterations have been made to the published papers in order to maintain argument continuity and consistency of spelling and style.

- Chapter 2 has been published as "The early-type galaxies NGC 1407 and NGC 1400 - I. Spatially resolved radial kinematics and surface photometry" in 2008, MNRAS, 385, 667 by Max Spolaor, Duncan A. Forbes, George K. T. Hau, Robert N. Proctor, and Sarah Brough.

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