PHIZ-EV: The growth of galaxies (project ID 277071)

Final Report

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Galaxies like our own Milky Way are conglomerations of billions of stars mixed together with gas, dust and dark matter. When we look at the images of galaxies in the local Universe we see that galaxies come in two main types. The first type is the impressive grand design spiral, with spiral arms extending outwards from a central bulge. This type of galaxy is generally blue in colour, which means that they are full of young, hot stars. Therefore we diagnose that they are currently in the process of converting their gas into stars. The second type of galaxy is the elliptical, a rugby-ball shaped galaxy which is generally red in colour. The red colour arises because the stars are predominantly old and cool, from which we know that the galaxy has stopped converting gas into stars. These two types of galaxies form the main arms of the Hubble sequence or "Tuning fork".
This research is concerned with why we see these two types of galaxies. What makes one galaxy stop forming stars, when its neighbour still has a plentiful supply of gas which it is converting into stars? The answer to this question is crucial in building a complete picture of how galaxies were first formed, and how they have evolved into the grand systems that we see around us in the local Universe today.

The primary science objective of this project was to extract more physical information from multi-waveband photometry of galaxy populations around z~2 than has ever been achieved so far, in order to build a better understanding of how galaxies grow. This was accomplished by (i) the analysis of the deepest multi-wavelength photometric dataset currently available; (ii) using modern statistical tools to extract more information than ever before from a photometric dataset; (iii) state-of-the-art spectral synthesis models and (iv) the concurrent development of a galaxy evolution model calibrated at high-z to interpret the observational data.

During this project we developed a new method to characterise the composition of galaxies in the distant Universe, in order to ascertain their recent history of star formation. We used this method analysed the CANDELS dataset, the deepest multi-wavelength photometric dataset currently available including rest-frame optical/NIR photometry which allows us to trace the stellar mass of galaxies in the distant Universe. Our research is opening entirely new windows on our understanding of the physical processes responsible for galaxy growth, improving on previous analyses so far which have focused on the derivation of basic physical properties (e.g. mass-to-light ratio) from indirect tracers of star formation. We have also developed a new method to identify recent merger signatures from images of galaxies, and linked this to the timescales for star formation using information from the spectra. Finally, we have identified emission lines as a significant contaminant in photometric datasets of normal star-forming galaxies at z~1-2, and characterised the strength of this contamination by comparing with state-of-the-art semi-analytic models.

During the period of the grant the fellow has given 5 invited talks and reviews at international conferences, 5 contributed talks at national and international conferences and seminars 8 UK and EU major European research institutes and several smaller departments in the UK. All talks were in part informed by results from this research project. The Fellow also lectures in Galaxy Evolution at the University of St Andrews, and is responsible for in 2013/14 completely redesigned the Extragalactic Astronomy course taken by 3rd/4th year students. In March 2012 she was invited to give 3 lectures on Stellar Populations, as part of the Lund Observatory (Sweden) graduate lecture series. This provided material to develop a SUPA “Galaxies” course, which was developed and ran in 2012/13. This involved co-ordinating 4 different lecturers from across Scotland, including the fellow, to deliver 12 advanced level lectures in their fields.

The project has aided the Fellow in obtaining a permanent academic position as lecturer at the University of St Andrews, where she now leads a group of 4 PhD students and 3 post-docs. On arriving at the School of Physics and Astronomy in January 2012 she was the only person in the School working in the field of Extragalactic Astronomy; there are now 2 lecturers, 2 advanced fellows, 4 post-doctoral researchers and 5 PhD students working directly in the group. The ERC starting grant of the Fellow has allowed the hiring of 3 post-doctoral researchers, and has attracted 3 PhD students with additional external funding. The School has supported the hiring of a second temporary lecturer in the field, who has since also obtained a Leverhulme Fellowship. The group has additionally attracted 2 advanced fellows with external funding (an STFC Ernest Rutherford Fellow and a SUPA advanced fellow) and an STFC funded post-doctoral researcher. Two further STFC funded PhD students are now part of the group, working with the SUPA and Leverhulme fellows. This has led to an active and thriving new Extragalactic Astronomy group, with a weekly journal club and up to date website (http://www-star.st-and.ac.uk/~vw8/Galaxies/GalaxiesGroup/Welcome.html).