New Dimensions in Galaxy Evolution

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The aim of this project was to develop techniques and science analysis to support next generation astronomical instruments that provide spatially resolved spectroscopy. This technique allows us to measure the spectrum of light at many points across the face of a galaxy, and so measure the motion of gas and stars, the location of star formation, the ages of stars, the heavy element content of gas and stars, the source of gas ionization and much more. The focus is specifically on the current SAMI instrument and the future HECTOR instrument that can observe many galaxies at once in this mode (12 for SAMI and 100 for HECTOR). This multiplexing allows us to understand the complexity of galaxy formation because we can target sufficient numbers of galaxies to span the full range of properties.

Outcomes
(1) The SAMI Early Data Release. Dr Allen led the publication of the first data release of the SAMI Galaxy Survey (Allen et al. 2015a) that presented new data from the SAMI Galaxy Survey, including detailed quality assessment. Published a little over a year ago, this paper has already been cited 30 times. Dr Allen has been one of the driving forces behind the survey, leading the development of the data reduction pipeline and data quality control. Several novel techniques have been implemented, to optimally combine and calibrate the data.

(2) Examining evidence for binary super-massive black holes. As galaxies merge it is expected that the black holes at their centres also eventually merge (and give rise to gravitational waves). Using SAMI data we have examined examples of possible binary super-massive black holes (Allen et al. 2015b). The rich data set provided by SAMI allowed us to show that the signatures that had previously been used to infer a possible super-massive black hole binary are in fact cause by other effects. The gas emission lines that are offset in velocity from the host galaxy can also be caused by either externally accreted gas or by outflowing gas driven by radiation from accretion onto the black hole.

(3) Applying new analysis methods to quasar spectra. In a series of papers (Bowler et al. 2014; Wildy et al. 2015; Richardson et al. 2016) Dr Allen has developed and applied his methods using independent component analysis (ICA) to construct optimal spectral models of luminous accreting super-massive black holes (quasars). This has led to new discoveries including that outflows from quasars are largely driven by line-absorption and discovery of new time-variable outflows.

(4) New analysis of star formation in SAMI Galaxies. Dr Allen and Prof Croom have co-supervised PhD student Adam Schaefer who is focussing his research on using SAMI to investigate how the external environment around a galaxy influences the spatial distribution of star formation. The radial star-formation profiles in high-density environments are found to be more centrally concentrated. This implies that the dense environment in quenching star formation in the outer parts of galaxies. A paper on this subject has been submitted to the journal Monthly Notices of the Royal Astronomical Society (MNRAS).

(4) Development of the HECTOR science case. In the first phases of HECTOR development, Dr Allen has been contributing to the development of the science case and survey design. This particularly includes assessment of the optimal data processing. The first version of the science case document was submitted to the Australian Astronomical Observatory at the end of 2015.