The Evolutionary History of Dusty Early-Type Galaxies From ALMA-Observed Cool ISM Content and Distribution

University of Central Lancashire UCLan

David H W Glass, Anne E Sansom

Jeremiah Horrocks Institute, University of Central Lancashire, Preston, UK

Jeremiah Horrocks Institute For Mathematics, Physics and Astronomy

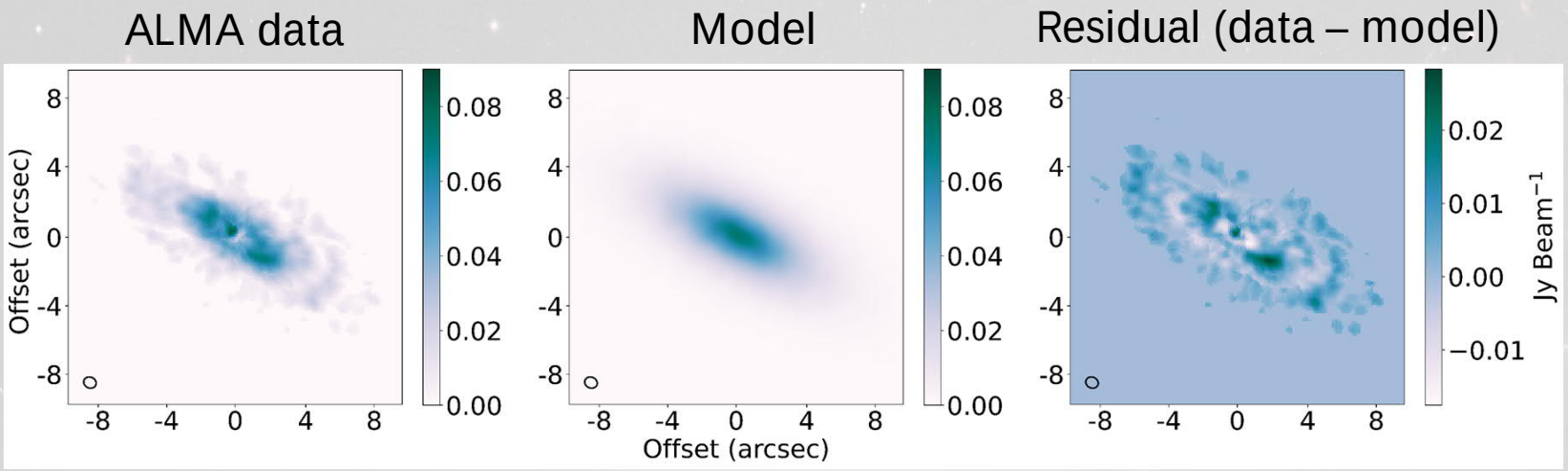
BACKGROUND

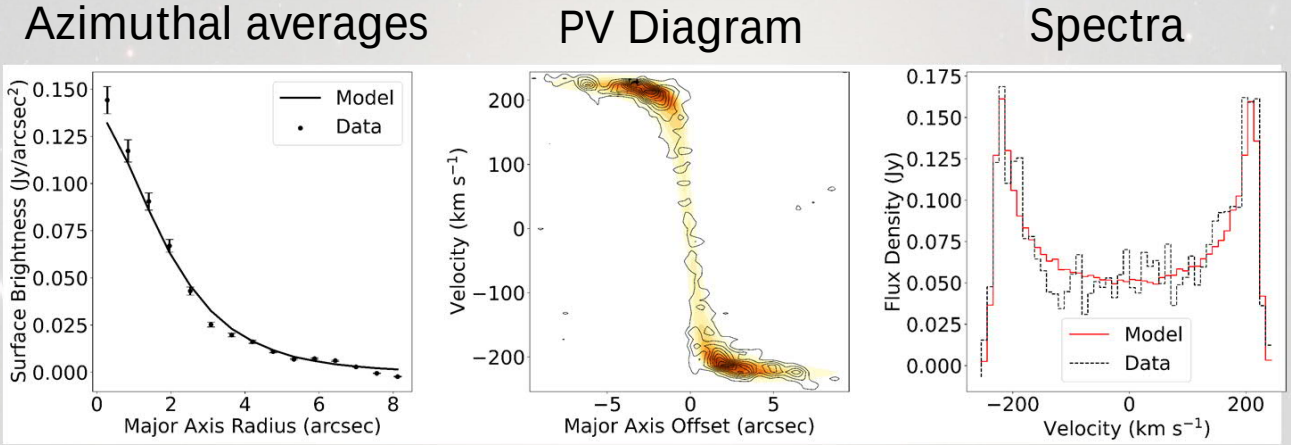
- Cool interstellar medium (ISM, gas and dust) content and distribution in early-type galaxies (ETGS) can indicate mechanisms involved in their evolution.
- EXAMPLE – kinematic misalignment between molecular gas and stars suggests accretion or merger activity (Davis et al. 2011).
- Three ETGs from the GAMA equatorial field (Driver et al. 2009) with high dust masses (from Herschel-ATLAS observations, Valiante et al. 2016) were found to have massive molecular gas reservoirs from ALMA observations (Sansom et al. 2019).
- Axisymmetric kinematic models are fitted to these ALMA observations using KinMS (KINematic Molecular Simulation, Davis et al. 2013).
- Aim is to highlight any additional structural features in the molecular gas and test whether evolutionary mechanisms can be identified.

GAMA64646, KiDS gri image

RESULTS – MODEL FITTING

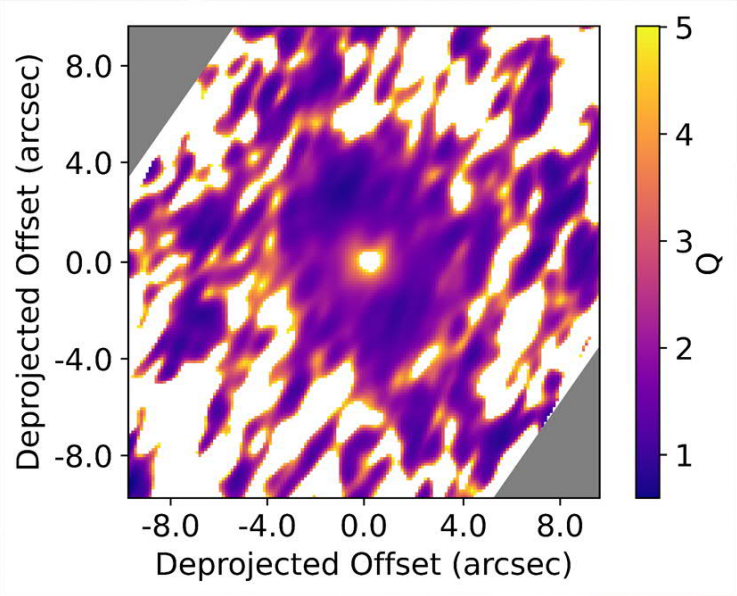
- Results for GAMA64646 shown below.
- Residual zeroth-order moment map (data – model) (*below*) shows a bright central feature, and symmetric inner and outer rings in addition to the model single-component gas disc with Sérsic surface brightness profile. These features are also apparent in the azimuthal average surface brightness plot.
- Position-Velocity (PV) diagram shows that an arctangent-based rotation curve model works well. Spectrum is generally symmetric.

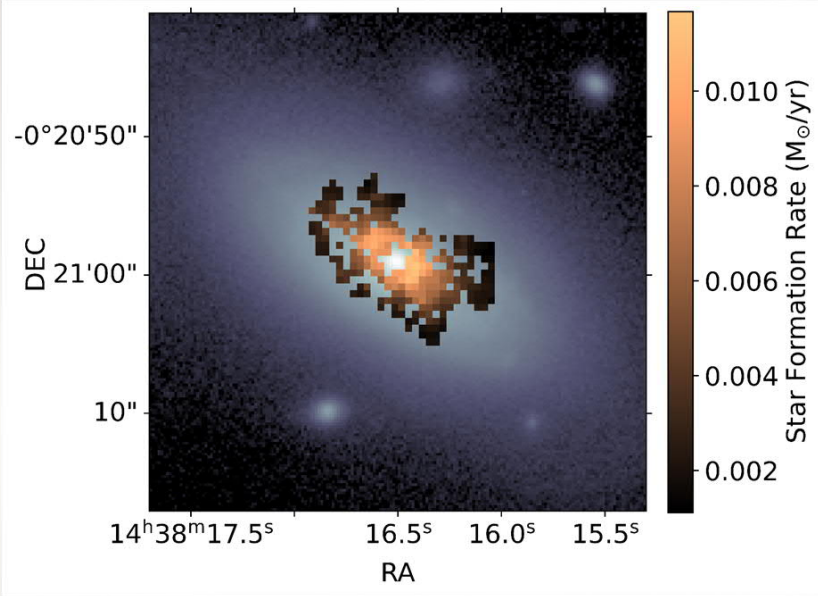




RESULTS – COMPARISONS WITH SAMI GALAXY SURVEY DR3 DATA

- SAMI DR3 (Croom et al. 2021) includes star formation maps and kinematic maps for stars and ionised gas from Integral Field Unit (IFU) observations.
- Stars, ionised gas and cool molecular gas are all well-aligned for all three ALMA-observed ETGs. Any disruption to the ETGs probably occurred >100 Myr ago (e.g. Tohline et al. 1982), allowing time for alignment to be re-established.
- Map of Toomre stability criterion (Q, Toomre 1964) calculated from ALMA data and model for GAMA64646 (*below left*) shows features in common with SAMI star formation map (*below right*, overlain on KiDS r-band log-normalised image) – star formation in the inner ring and no star formation at the centre. Because of uncertainties in molecular gas mass estimates, Q<2 indicates possible star formation with increasing likelihood at lower values.





RESULTS FOR THE OTHER GALAXIES

- GAMA272990 – Residual zeroth-order molecular gas map shows a bright central feature and an outer ring in addition to a single-component disc. Star formation is predicted throughout these features by the Q map, confirmed by the SAMI star formation map.
- GAMA622429 – Modelled with an axisymmetric gas disc and a small edge-on disc representing a bar-like feature. Residual asymmetric molecular gas spiral features apparent. Star formation is predicted in a patch on one side and along the opposite spiral feature. The former is confirmed in the SAMI star formation map.

CONCLUSIONS AND FUTURE WORK

- Two of the observed ETGs appear to have been disturbed based on molecular gas distribution and other evidence, leading to reconfiguration of the molecular gas.
- GAMA622429 appears to have acquired additional molecular gas, causing the asymmetric patch of star formation.
- We have 30 dusty ETGs observed for molecular gas with the IRAM 30m telescope (Glass et al., in prep.), from which we can draw more targets for a larger survey.

REFERENCES

Croom S. M., et al., 2021, MNRAS, 505, 991
Davis T. A., et al., 2011, MNRAS, 417, 882
Davis T. A., et al., 2013, MNRAS, 429, 534
Driver, S.P. et al., 2009, A&G 50 5.12-5.19
Sansom A. E., et al., 2019, MNRAS, 482, 4617
Tohline J. E., Simonson G. F., Caldwell N., 1982, ApJ, 252, 92
Toomre A., 1964, ApJ, 139, 1217
Valiante, E. et al., 2016, MNRAS 462 3146-3179

ACKNOWLEDGEMENTS

DHWG has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 (RadioNet). KiDS image from Lee Kelvin.