Complexity and scatter in kpc-scale star formation scaling relations in ALMaQUEST: (ALMA-MaNGA QUEnching and STar formation survey)

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http://arc.phys.uvic.ca/~almaquest/
THE STAR-FORMING MAIN SEQUENCE AND OUTLIERS

NUMBER OF STARS FORMING

NUMBER OF EXISTING STARS

STARBURSTS

THE MAIN SEQUENCE

THE GREEN VALLEY

RED AND DEAD GALAXIES
Radial profiles of relative SFR:
Star formation is boosted and quenched from the inside out.

Ellison et al. (2018)
The ALMaQUEST Survey:
46 MaNGA selected galaxies observed in CO(1-0) with ALMA.

Resolution (~kpc) matched molecular gas maps ($\Sigma_{H_2}$) complement the MaNGA data products, such as $\Sigma_*$ and $\Sigma_{SFR}$.

Sample includes galaxies on the SFMS, in the green valley and those with central starbursts.

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Lin et al. (2020, submitted)
Resolved (kpc) scaling relations in star forming galaxies

The resolved Schmidt-Kennicutt relation (rSK)

Ellison et al. (submitted); See also Lin et al. (2019)
Resolved (kpc) scaling relations in star forming galaxies

The resolved star forming main sequence (rSFMS)

Ellison et al. (submitted); See also Lin et al. (2019)
Resolved (kpc) scaling relations in star forming galaxies

The resolved molecular gas main sequence (rMGMS)

Ellison et al. (submitted); See also Lin et al. (2019)
Resolved (kpc) scaling relations in star forming galaxies

Three star forming scaling relations: rSK, rMGMS and rSFMS. The rSFMS arises as a result of the rSK and rMGMS and is not fundamental.

Lin et al. (2019)
Galaxy-by-galaxy (kpc) scaling relations

The resolved Schmidt-Kennicutt relation (rSK)

Ellison et al. (submitted)
Galaxy-by-galaxy (kpc) scaling relations

The resolved star forming main sequence (rSFMS)
Galaxy-by-galaxy (kpc) scaling relations

The resolved molecular gas main sequence (rMGMS)
Galaxies show considerable variation in the scaling relations

The offset of a given galaxy from the average relation correlates with global properties, such as morphology.

Star formation scaling relations are not universal. There is considerable galaxy-to-galaxy variation in the three resolved star formation scaling laws and correlations with global galaxy quantities.

Ellison et al. (submitted)
What about non-star-forming spaxels? The resolved molecular gas main sequence in `retired’ spaxels.

Retired spaxels have lower gas fractions than star-forming spaxels

Ellison et al. (in prep)
Even within a given galaxy, retired regions have lower average gas fractions than their star-forming regions. Decline (but not absence) of gas is a plausible reason for the onset of quenching.
The central location of the retired spaxels indicates that retirement happens from the inside-out.
An artificial neural network analysis of ~11,500 spaxels.

Whilst $\Sigma_{H_2}$ is the most important for predicting $\Sigma_{SFR}$, SFE (and variations therein) drive scatter around the rSFMS (i.e. $\Delta \Sigma_{SFR}$).

Ellison et al. (2020a, b)
Summary

• The ALMaQUEST survey consists of 46 galaxies with MaNGA+ALMA CO(1-0) observations at ~kpc scale resolution: Lin et al. (2020, submitted).

• There is significant galaxy-to-galaxy variation in all 3 scaling relations, which drives the shape and scatter of the ensemble relations. The individual galaxy scaling relations correlate with global galaxy parameters, e.g. Sersic N: Ellison et al. (submitted).

• The rMGMS of retired spaxels is offset to lower gas fractions compared with star forming spaxels, even with the same galaxy. Depleted gas reservoirs play a role in quenching, which happens from the inside out: Ellison et al. (in prep).

• Whilst $\Sigma_{H2}$ is the most important for predicting $\Sigma_{SFR}$, SFE (and variations therein) drive scatter in the rSFMS (i.e. $\Delta\Sigma_{SFR}$), with gas fraction in a secondary role: Ellison et al. (2020a,b).

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