MegaSaura: a spectroscopic sample of lensed starbursts at Cosmic Noon

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Introduction

The Magellan Evolution of Galaxies Spectroscopic and Ultraviolet Reference Atlas (MegaSaura, Rigby+ 2017a,b) consists of intermediate-resolution, rest-frame UV Spectroscopic Magellan/MagE observations of a sample of 15 bright, star-forming galaxies at "Cosmic Noon" ($1.5 \lesssim z \lesssim 3.5$).

Strongly lensed and rest-frame UV bright

MegaSaura are selected to be bright in the optical and have redshifts in the range $1.5 \lesssim z \lesssim 3.5$, when the majority of the stars in the current Universe formed. They are selected to be bright in optical (rest-frame UV) bands, which indirectly selects for a strong population of young, hot stars. This makes the sample comparable to e.g. the Lyman Alpha Reference Sample (Östlin+ 2014, Hayes+ 2014).

Early results from kinematics

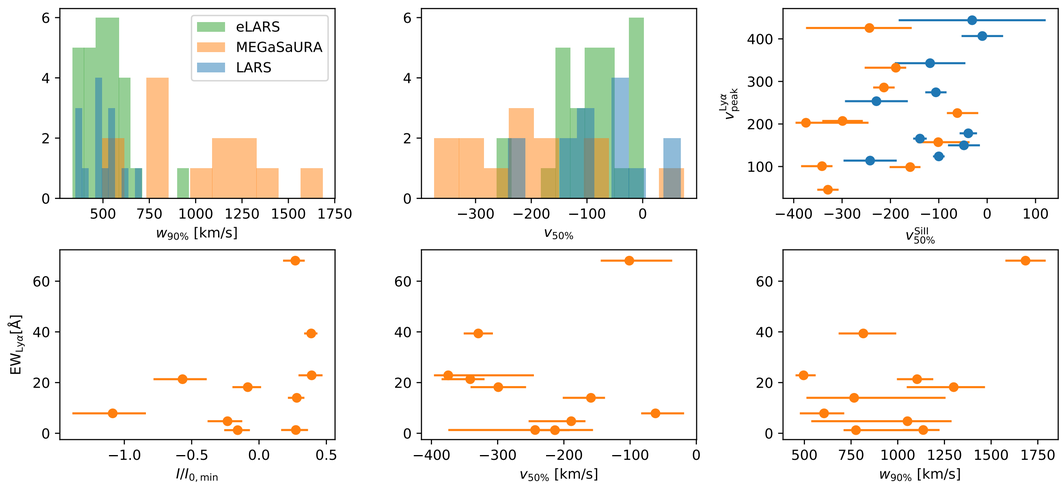

Figure: Early results from MegaSaura kinematics, compared to measurements from (e)LARS. If EW(Lyα) is a fair proxy for escape fraction, the dependence on neutral wind velocity ($v_{50\%}$) and line depth ($I/I_{0,\mathrm{min}}$) and -thickness ($w_{90\%}$) show no surprises compared to low redshifts, but winds are generally faster and with much higher maximum wind speeds.

The Sunburst arc — a late but unique arrival

Bright, large, metal-poor starburst

PSZ1-ARC G311.65-18.48 was observed afterMegaSaura proper and is not included in Rigby+ 2016a,b, will be included in future analyse. It is the brightest arc ever observed and may well be the brightest arc to ever be observed (Dahle+ 2016). It extends 55" over the Southern sky, an order of magnitude more than most MegaSaura galaxies. We nicknamed it the "Sunburst" due to the way rifts in the medium allow a direct view of the hot stars behind it.

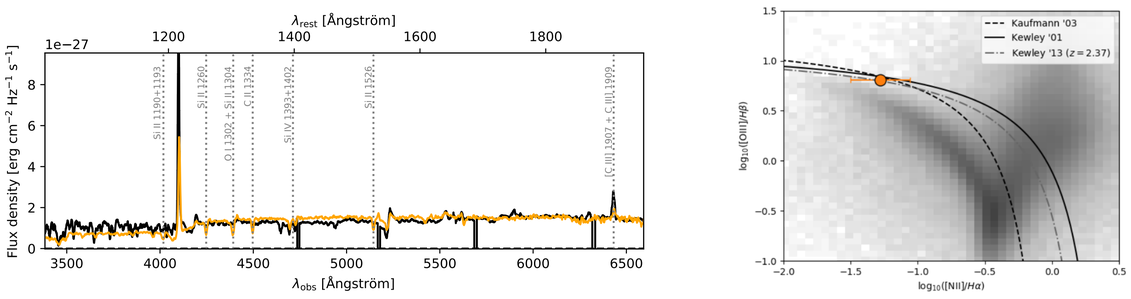

Figure: Left: The Sunburst Arc shows strong similarity to the stacked Lyman Break Galaxy spectra of Shapley+ 2003. Right: A BPT analysis based on FIRE spectroscopy reveals that the galaxy is metal poor but quite typical for a starburst galaxy at its redshift.

Triple-peaked Lyα emission line

Visual inspection of one of the MagE pointings revealed a very unusual, triple-peaked Lyα profile, theoretically predicted to arise when Lyα radiation escapes through direct, empty channels in a medium of otherwise high column density (e.g. Behrens+ 2014). To our knowledge, this is the first time such a profile has been observed unambiguously (Rivera-Thorsen+ 2017b).

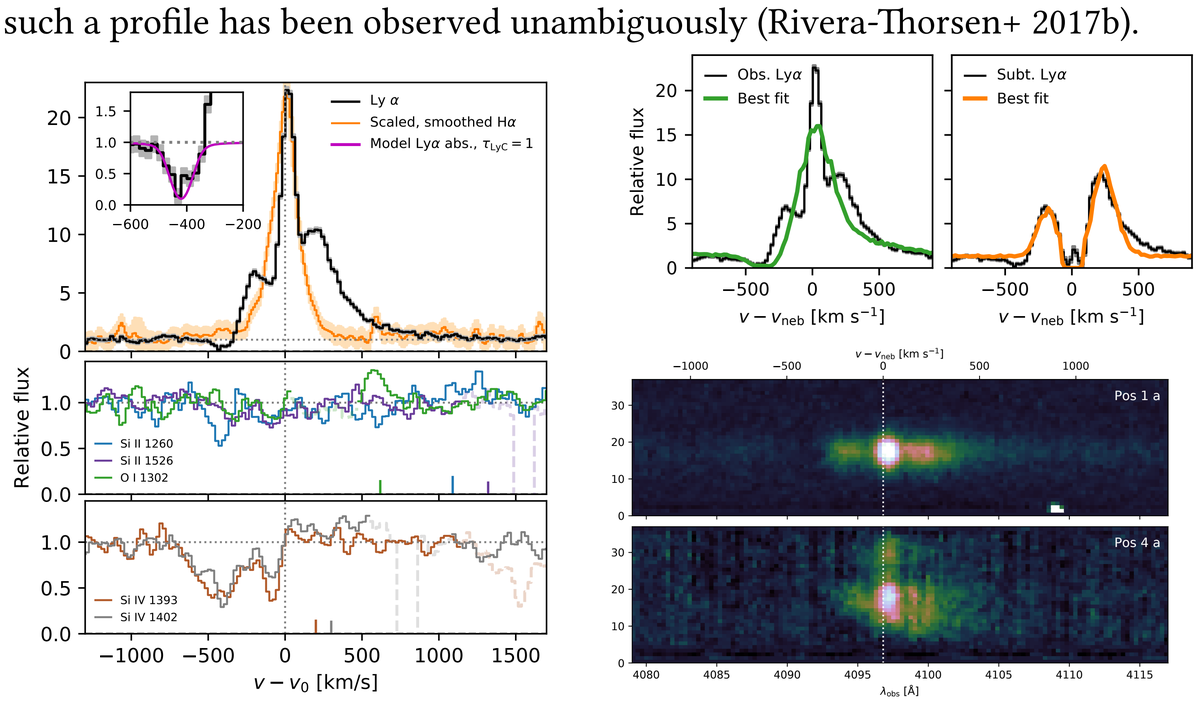

Figure: **Clockwise:** 1: *Upper panel*: Lyα and Hα. The central peak in Lyα is almost completely unaffected by neutral gas. Inset: Computed worst-case Lyα profile of high-velocity HI gas of 1 optical depth ($\sim$ 70% abs.) in LyC. *Middle panel:* Select neutral absorption lines. Very shallow but follows the features found in Lyα at ~ -100 and ~ -450 km/s. *Lower panel* Ionized gas is more abundant but follows the same general kinematic structure. 2: Lyα could only be modeled with an isotropic outflow model if we removed the narrow peak at line center. 3: 2D-spectra of Lyα in position 1 and 4, only the former has yet been published.

HST Imaging

Recently, we obtained HST F814W imaging data of the arc (Prop. 15101, PI Dahle). The images revealed a wealth of detail and complexity.

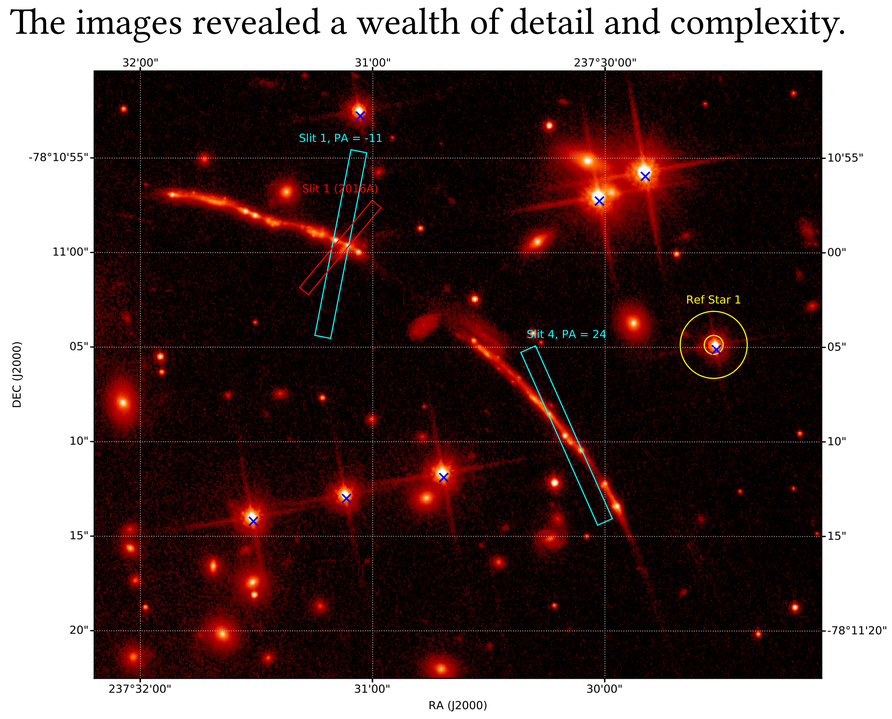

Figure: HST F814W image of the two brightest sub-arcs, with Fire (red) and MagE (cyan) slits overlaid. The observations of Position 1 were published in Rivera-Thorsen+ 2017, analysis of other pointings is still incomplete.

Imaging in rest-frame Lyman-Continuum is scheduled for late April. If detected, these observations can probe ionizing radiation escape down to $\lesssim$ kpc scales, which will be another first made possible by this system.

Lens models suggest extreme magnification

Preliminary lens models suggest that this arc consists of a large number of images of the same, relatively simple structure It consists of one bright, compact cluster (point-like at HST resolutions), and a group of fainter, fuzzier clumps (see figure below). Lens modeling so far shows that the galaxy is imaged 6 times in the NE sub-arc alone — modeling of the other sub-arcs is still ongoing.

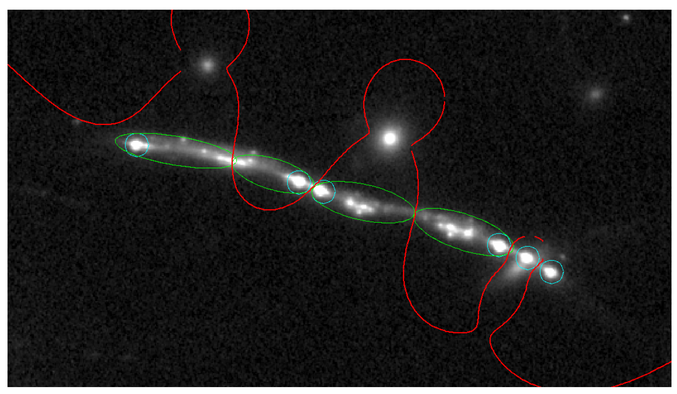

Figure: Preliminary critical lines (red) overlaid on HST imaging of the upper third of the arc. Cyan rings indicate multiple images of the source. Image credit: Keren Sharon, Univ. of Michigan

The MagE observations reported in Rivera-Thorsen+ 2017b were pointed at the triple image of the bright cluster in the lower right of the image.