SINFONI Observations of Galaxy Dynamics and Assembly at \( z \sim 2 \)

Kristen Shapiro and the SINS team
Galaxy Assembly and Evolution at $z \sim 2$

Large, rotating disks are important at high-$z$

They are clumpy, thick, rapidly star-forming

They are assembled by cold flows

They are forming bulges secularly

The backbones of local scaling relations are in place

*Bouché et al. 2007; Cresci et al. in prep; Förster Schreiber et al. 2006, in prep; Genel et al. 2008; Genzel et al. 2006, 2008; Shapiro et al. 2008, in prep*
• JHK Integral Field Spectroscopy
• 0.125"/pixel; FOV = 8” x 8”
• R = 2000-4500

PIs: F.Eisenhauer, H.Bonnet
SINFONI at $z \sim 2$

- JHK $\rightarrow$ Rest-Frame Optical ($H\alpha$ Emission)
- $1'' \sim 8.2$ kpc
- 1-11 hours of integration on 80 objects

PI: R. Genzel
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PI: R. Genzel
The Survey

Förster Schreiber et al. in prep
The Survey

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The Survey

Förster Schreiber et al. in prep
The SINS Survey

Förster Schreiber et al. in prep
There are large disks at z~2
There are large disks at $z \sim 2$

Kinemetry analysis of first and second velocity moment for highest quality SINS data

$$K(\psi) = A_0 + A_1 \sin(\psi) + B_1 \cos(\psi)$$
$$+ A_2 \sin(2\psi) + B_2 \cos(2\psi)$$
$$+ A_3 \sin(3\psi) + B_3 \cos(3\psi) \ldots$$

Krajnović et al. 2006

Shapiro et al. 2008
High-z disks are clumpy

Förster Schreiber, Shapley et al. in prep, see also e.g. Elmegreen & Elmegreen 2007
High-z disks are clumpy, unlike merger remnants

Figures from Genzel et al. 2006, Robertson & Bullock 2008
Super SF clumps are massive

$M_{\text{SF Region}} \sim 10^8 M_\odot$

$\sim 8-10$ clumps / galaxy

e.g. Genzel et al. 2006, Elmegreen & Elmegreen 2006
High-z disks are thick

$V/\sigma \sim 1-7$

(from detailed dynamical modeling of 19 systems)

Genzel et al. 2008, Cresci et al. in prep
High-z disks form stars continuously

$H\alpha$ Intensity  $V$ (km/s)  $\sigma$ (km/s)

SFR $\sim$ 30-200 $M_\odot$/yr

High-z disks form stars continuously

$M_\ast \sim 8 \times 10^{10} \, M_\odot$

SFR $\sim 100$-$200 \, M_\odot/\text{yr}$

Age $\sim 500$ Myr

Förster Schreiber et al. 2006, in prep, Genzel et al. 2006, 2008, see also Daddi et al. 2007
Cold flows are the dominant accretion mechanism

\[
\frac{V}{\sigma} \sim 1-7
\]

\[t_{\text{accretion}} \sim 200-800 \text{ Myr}\]

SFR \sim 30-200 M_\odot/\text{yr} and is continuous

e.g. Dekel et al. 2008

Genzel et al. 2006, Shapiro et al. 2008
Central concentrations are forming

Genzel et al. 2008

Local scaling relations are appearing

\[ z \sim 1.5 \quad z \sim 2.2 \]

\[ \log V (\text{km/s}) \]

\[ \log M_* (M_\odot) \]

Cresci et al. in prep
Local scaling relations are appearing
... maybe even BH scaling relations

+ Genzel et al. 2008 dynamical modeling of bulge masses

Shapiro et al. in prep
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