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от Сильченко О.К.

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EVOLUTION OF INTERSTELLAR MEDIUM, STAR FORMATION, AND ACCRETION AT HIGH REDSHIFT

N. Scoville[1], N. Lee[3], P. Vanden Bout[2], T. Diaz-Santos[18], D. Sanders[8], B. Darvish[1], A. Bongiorno[4], C. M. Casey[5], L. Murchikova[1], J. Koda[6], P. Capak[7], Catherine Vlahakis[9], O. Ilbert[14], K. Sheth[10], K. Morokuma-Matsui[11], R. J. Ivison[16,17], H. Aussel[12], C. Laigle[13], H. J. McCracken[13], L. Armus [7], A. Pope[15], S. Toft[3], and D.Masters[7]

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ABSTRACT

ALMA observations of the long wavelength dust continuum are used to estimate the interstellar medium (ISM) masses in a sample of 708 galaxies at z = 0.3 to 4.5 in the COSMOS field. The galaxy sample has known far-infrared luminosities and, hence, star formation rates (SFRs), and stellar masses (M_*) from the optical-infrared spectrum fitting. The galaxies sample SFRs from the main sequence (MS) to 50 times above the MS. The derived ISM masses are used to determine the dependence of gas mass on redshift, M_*, and specific SFR (sSFR) relative to the MS. The ISM masses increase approximately 0.63 power of the rate of increase in SFRs with redshift and the 0.32 power of the $\mathrm{sSFR}/\mathrm{sSFR}_M S$. The SF efficiencies also increase as the 0.36 power of the SFR redshift evolutionary

Свойства выборки

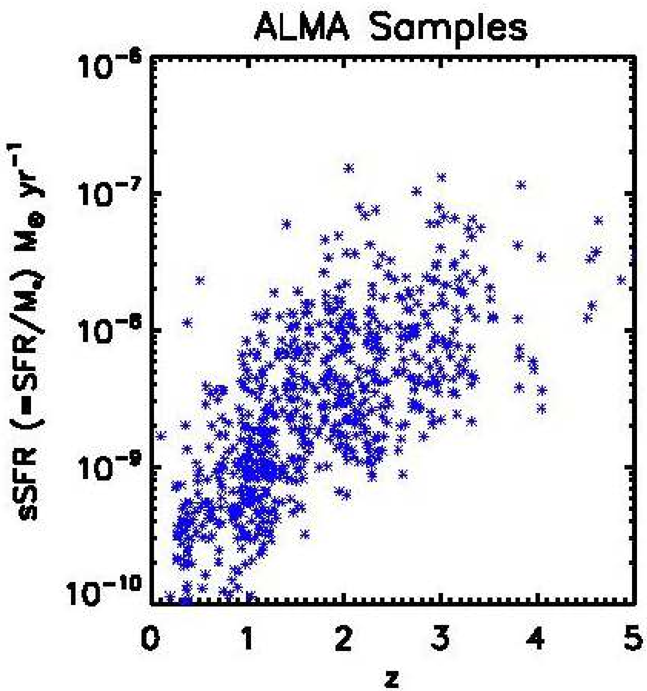


Figure 3. The distributions of sSFR and redshifts for the objects which were detected are shown.

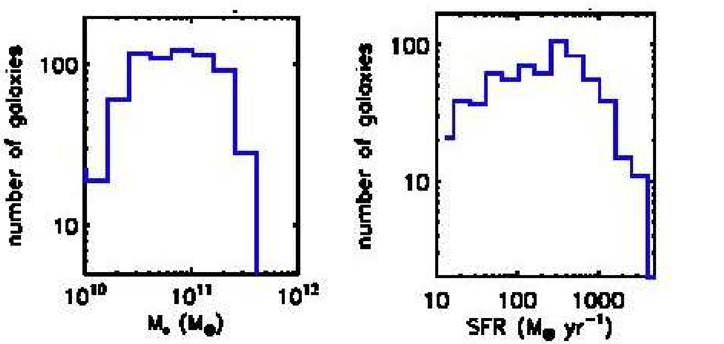


Figure 4. The distributions of stellar masses and SFRs for the detected objects.

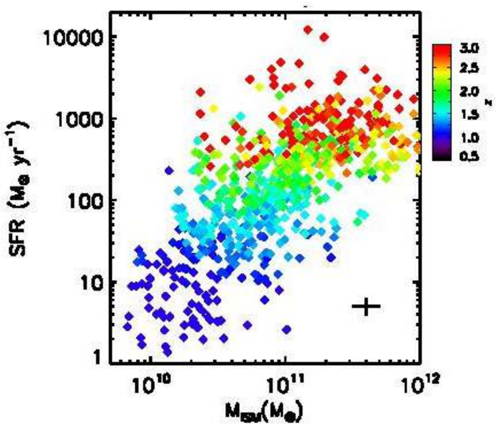


Figure 6. The SFRs and derived $M_{\rm ISM}$ are shown for 708 galaxies detected in the ALMA observations. Uncertainties in both quantities range from 10% to 50%; we show a typical error bar of 25% in the lower right corner. The observed spread in both x and y is much larger than this uncertainty, indicating that there must be other dependencies than a simple one-to-one correspondence between SFRs and ISM masses.

Основной подход

- Масса межзвездной среды определяется по потоку в Рэлей-Джинсовском FIR-континууме (данные ALMA); фиксируется температура пыли 25K и отношение массы пыли и газа 1%.

Модель эволюции на главной последовательности и наблюдательный результат

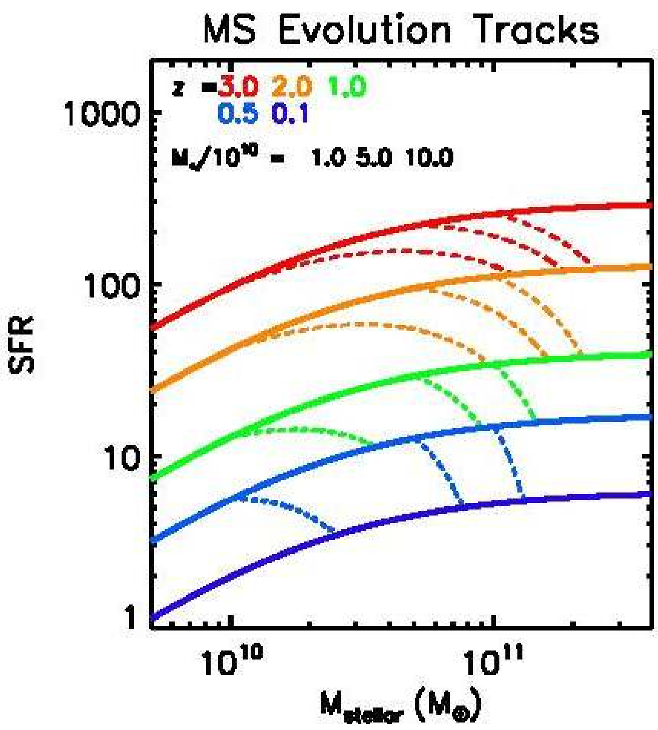


Figure 2. The evolution of the star forming galaxy MS evolves to lower SFRs at lower z for all stellar masses. The curved downward tracks (dashed lines) show the evolution of characteristic stellar masses (1, 5, and 10 $\times 10^{10} M_{\odot}$)between the MS lines at the adjacent redshifts – assuming that each galaxy stays on the MS (z) and its increase in stellar mass is given by integration of the SFR_{MS}

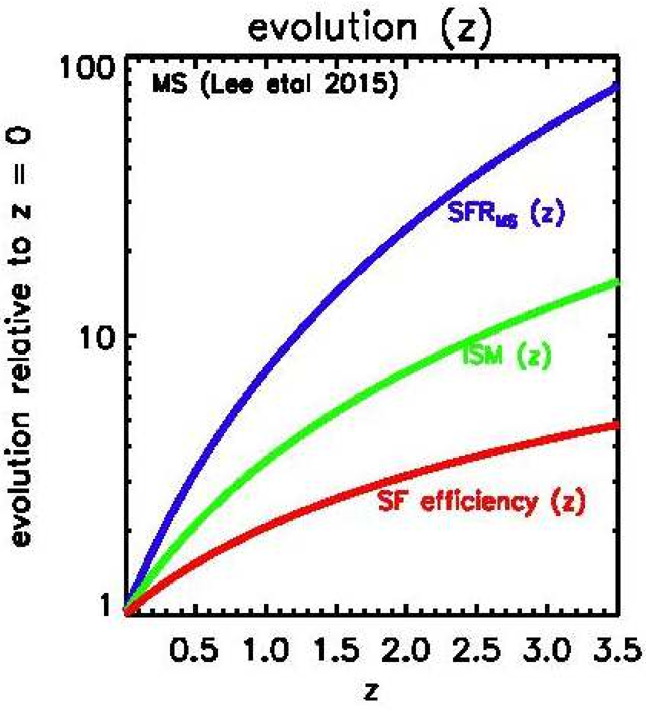


Figure 9. The evolutionary dependence of the SFRs (blue), the ISM masses (green) and the SF efficiency (red) per unit mass of ISM on the MS at a characteristic stellar mass of 5×10^{10} $M_{\odot}$.

Аппроксимацмя степенными функциями по трем параметрам

The result of the MCMC fitting for the dependence of the M_{ISM} on redshift, MS-Ratio and stellar mass is:

$$
\begin{aligned}
M_{ISM} = 7.07 \pm 0.88\ & \times 10^9\ M_\odot \\
& \times (1+z)^{\ 1.84 \pm 0.14} \\
& \times (sSFR/sSFR_{MS})^{0.32 \pm 0.06} \\
& \times \left(\frac{M_*}{10^{10} M_\odot}\right)^{0.30 \pm 0.04} .
\end{aligned}
\tag{6}
$$

The MCMC solution is:

$$
\begin{aligned}
SFR = 0.31 \pm 0.01\ M_\odot\ yr^{-1} \times \left(\frac{M_{ISM}}{10^9 M_\odot}\right) & \\
\times (1+z)^{1.05 \pm 0.05} & \\
\times (sSFR/sSFR_{MS})^{0.70 \pm 0.02} & \\
\times \left(\frac{M_*}{10^{10} M_\odot}\right)^{0.01 \pm 0.01} & .
\end{aligned}
\tag{7}
$$

Поделили одно на другое:

$$\tau_{\rm dep} \equiv M_{ISM}/SFR$$
$$= 3.23 \pm 0.10 \text{ Gyr } \times (1+\mathrm{z})^{-1.05\pm0.05} \times$$
$$(\mathrm{sSFR}/\mathrm{sSFR_{MS}})^{-0.70\pm0.02} \times \mathrm{M}_{10}^{-0.01\pm0.01} \;, \; (8)$$

$$\mathrm{f_{gas}} \equiv \frac{\mathrm{M_{ISM}}}{\mathrm{M_*} + \mathrm{M_{ISM}}}$$
$$= \{1 \; + \; 1.41 \pm 0.18 \times (1+\mathrm{z})^{-1.84\pm0.14} \times$$
$$(\mathrm{sSFR}/\mathrm{sSFR_{MS}})^{-0.32\pm0.06} \times \mathrm{M}_{10}^{0.70\pm0.04}\}^{-1} (10)$$

Вот как это выглядит графически:

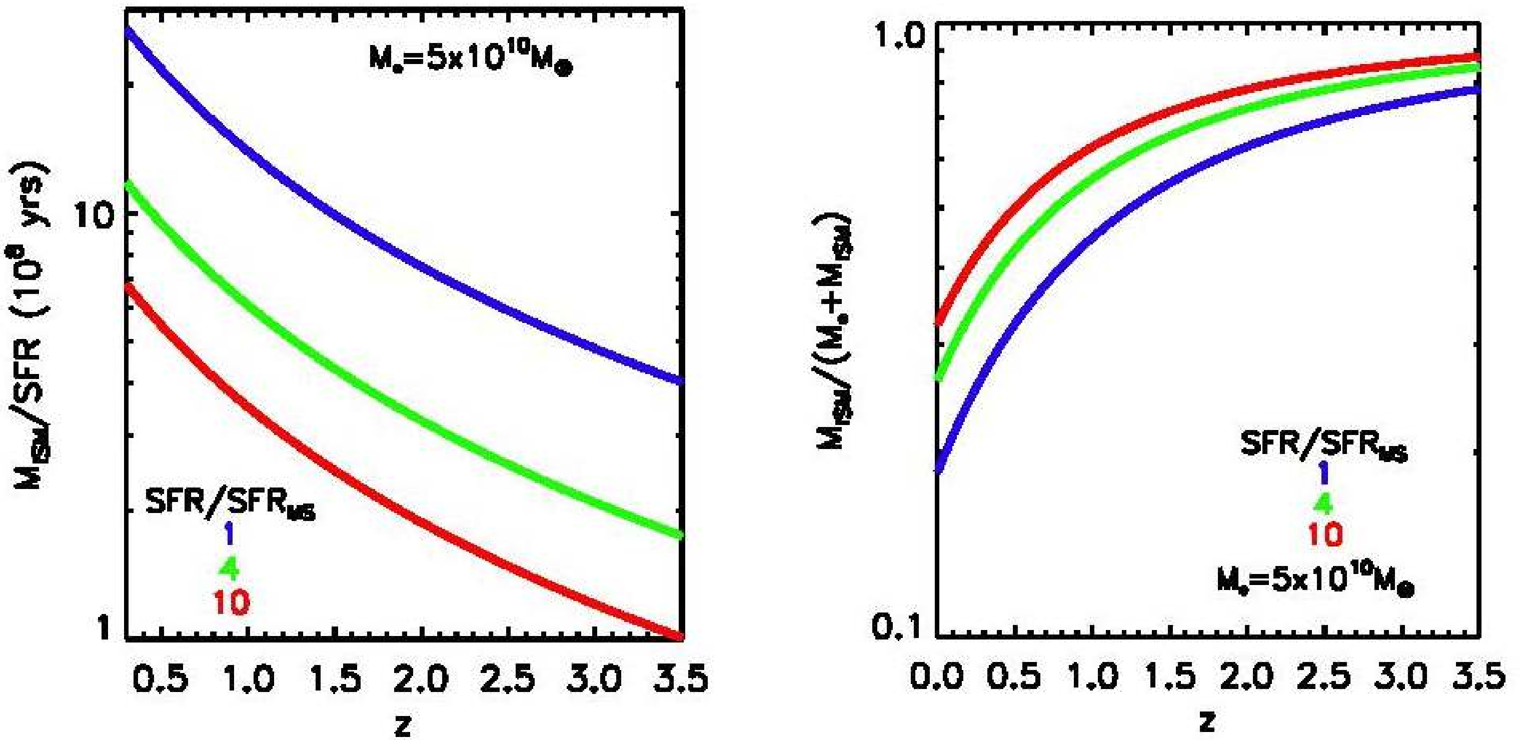


Figure 10. Left - The gas depletion times (M_{ISM}/SFR) obtained from combining Equations 6 and 7. Right - The gas mass fraction obtained from Equation 6. Both are shown for a fiducial mass $M_* = 5 \times 10^{10}$ $M_\odot$ and with sSFR = 1 (blue), 4 (green) and 10 (red) times that of the MS. The extrapolation of the ISM mass fraction to z = 0 is probably higher by a factor $\sim$2, compared to published values.

Приложили свою модель – получили темп аккреции:

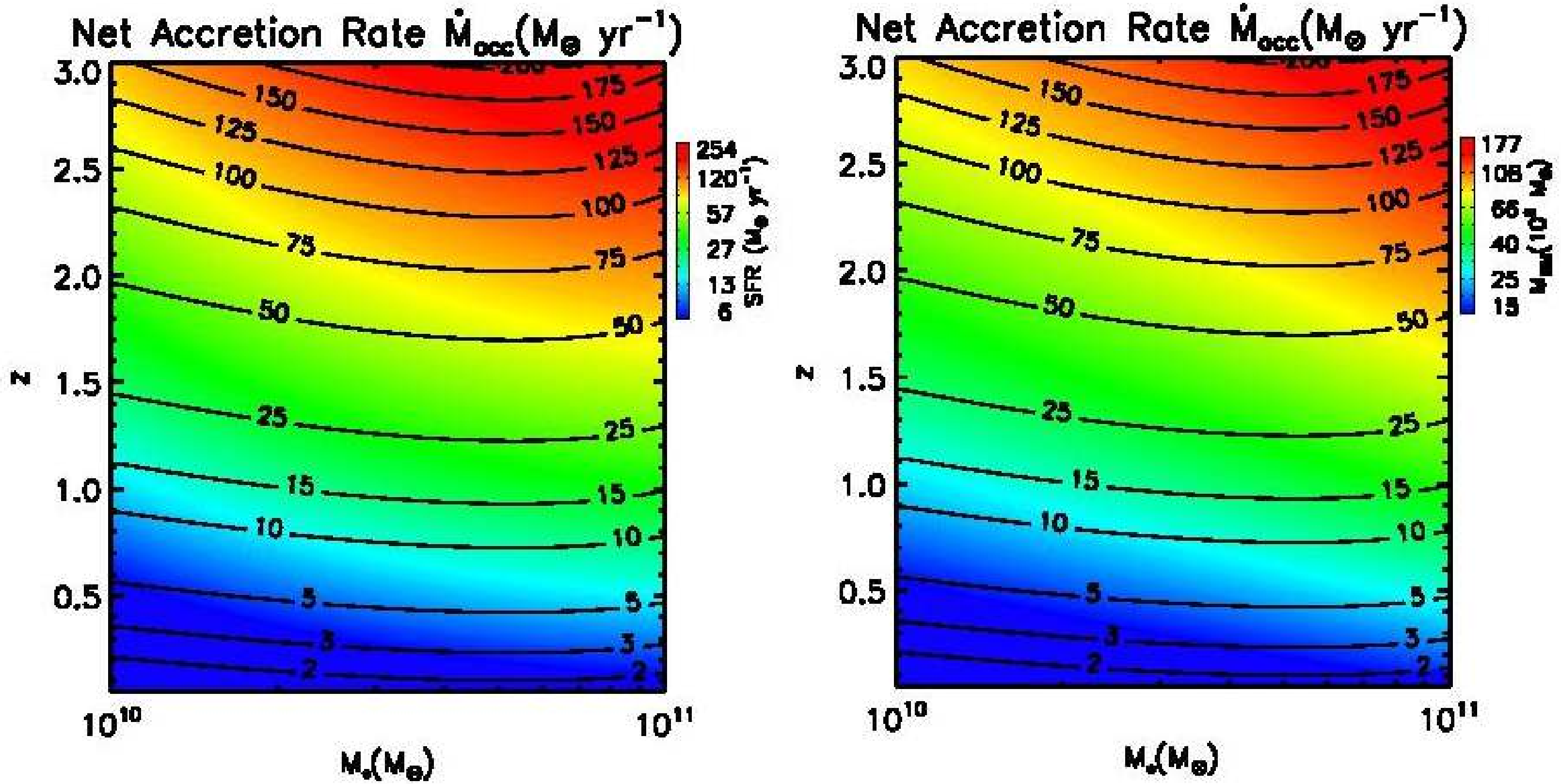
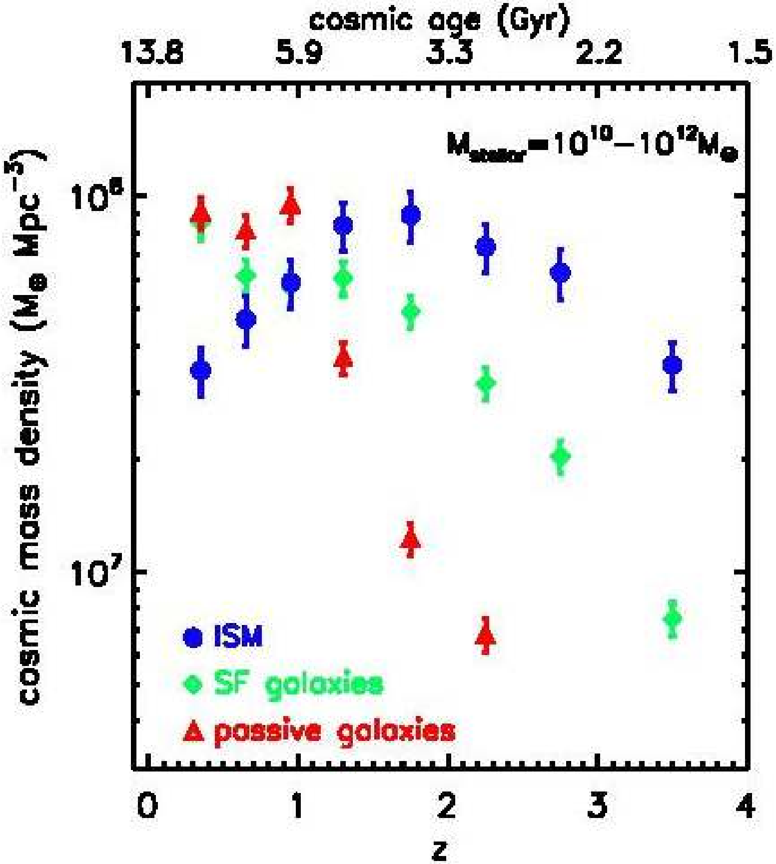
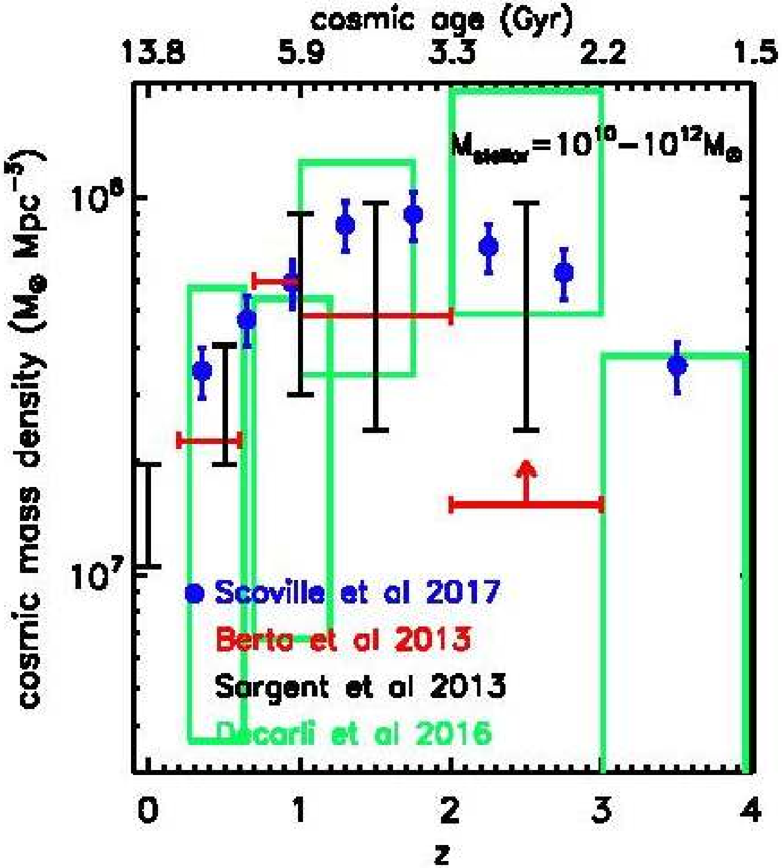


Figure 11. The net accretion rates (contours) calculated using Equation 11 with the ISM masses given by Equation 6, the SFRs from Equation 7 and the MS tracking from the assumption of continuity in the evolution of the MS galaxy population. In the Left panel, the color background is SFR_{MS}; in the Right panel it is M_{ISM} on the MS in units of $10^9 \mathrm{M}_\odot$. We adopt a 30% stellar mass-loss percentage (Leitner & Kravtsov 2011).

В глобальном масштабе:





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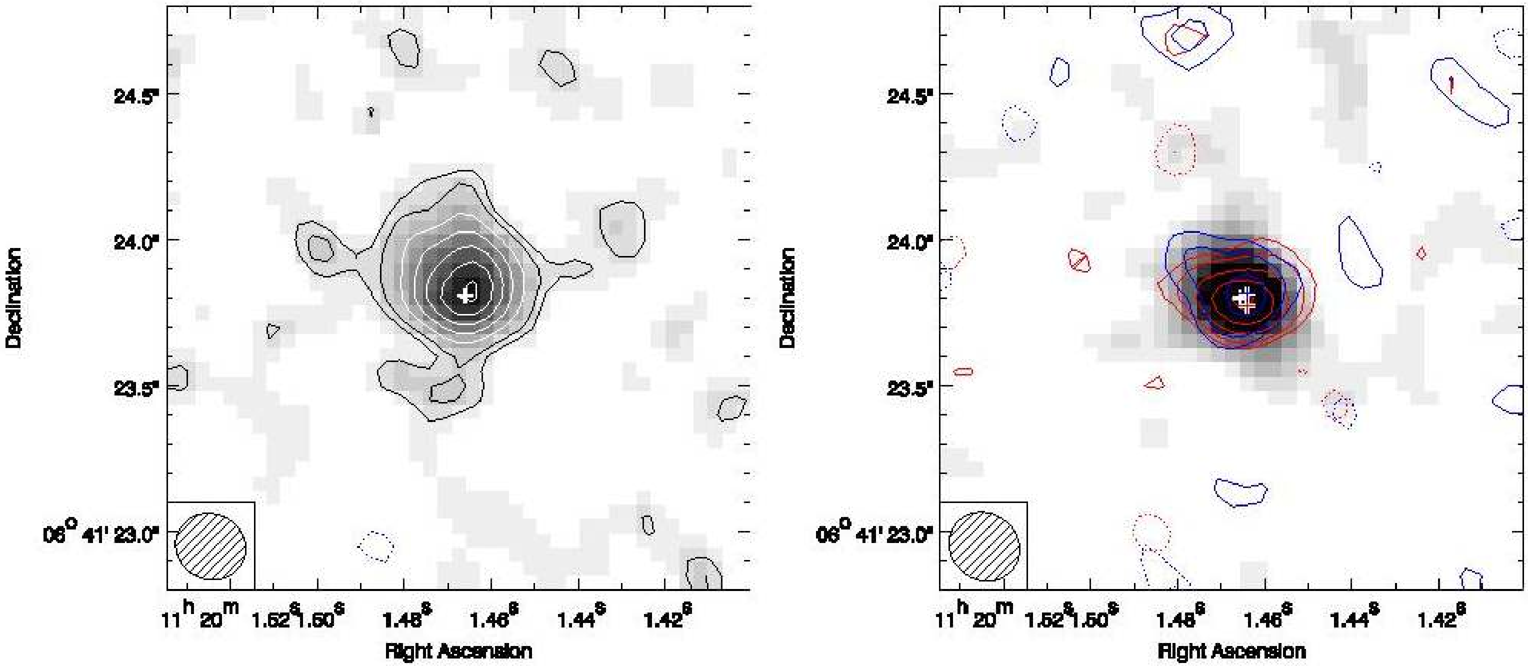
THE COMPACT, ~1 KPC HOST GALAXY OF A QUASAR AT A REDSHIFT OF 7.1

Bram P. Venemans[1], Fabian Walter[1,2,3], Roberto Decarli[1], Eduardo Bañados[4,12], Jacqueline Hodge[5], Paul Hewett[6], Richard G. McMahon[6,7], Daniel J. Mortlock[8,9,10], Chris Simpson[11]

Самый далекий квазар, с черной дырой в миллиард солнечных масс

In this paper we investigate the host galaxy of the most distant quasar currently known, ULAS J112001.48+064124.3 (hereafter, J1120+0641) at a redshift of $z = 7.085$ (Mortlock et al. 2011). The quasar is powered by a black hole with a mass of $(2.4 \pm 0.2) \times 10^9\, M_\odot$ (Mortlock et al. 2011; De Rosa et al. 2014) and is accreting close to the Eddington limit (Mortlock et al. 2011; De Rosa et al. 2014; Barnett et al. 2015). The quasar host galaxy has previously been detected with the Interferometer IRAM PdBI in [C II] and the dust continuum (Venemans et al. 2012). In these data the host galaxy was unresolved in a $\sim 2''$ beam and the dynamical mass and the morphology of the line emitting gas could not be constrained. Here we present high spatial resolution ($0\farcs23$, or 1.2 kpc) observations with ALMA (Section 2.1), decreasing the beam area by a factor of ~ 70. We also present observations with the

Результаты ALMA



igure 3. *Left:* Map of the [C II] emission in J1120+0641 (shown both in greyscale as well as contours), averaged over .5× $\mathrm{FWHM}_{[\mathrm{CII}]}$ (600 $\mathrm{km\,s^{-1}}$ or 470 MHz). The 1σ rms noise in this map is 42 μJy. The blue, dashed contours are -3σ and 2σ; the black, solid contours are $+2\sigma$ and $+3\sigma$; the white solid contours are $[5,7,9,11,13]\times\sigma$. The size of the beam is shown 1 the bottom-left corner. The white cross shows where the continuum emission of the quasar host peaks. *Right:* The red nd blue side of the emission line are shown in contours, averaged over 265 $\mathrm{km\,s^{-1}}$ centered at +265 $\mathrm{km\,s^{-1}}$ (red contours) and 265 $\mathrm{km\,s^{-1}}$ (blue contours) from the line peak. Contour levels are -2σ, $+2\sigma$, $+3\sigma$, $+5\sigma$, $+7\sigma$, and $+9\sigma$, with $\sigma \sim 57\,\mu$Jy. The reyscale is a representation of the continuum map. The white, red, and blue crosses indicate the peak of the total, redshifted, nd blueshifted [C II] emission, respectively.

ВЫВОД:

- Галактика не вращается;
- По дисперсии скоростей газа динамическая масса центральной области (R< 1 kpc) 10 млрд M(sun),
- То есть масса черной дыры только в 5 раз меньше!
- Газ возбужден НЕ квазаром, а звездообразованием; его темп 100-300 масс Солнца в год.

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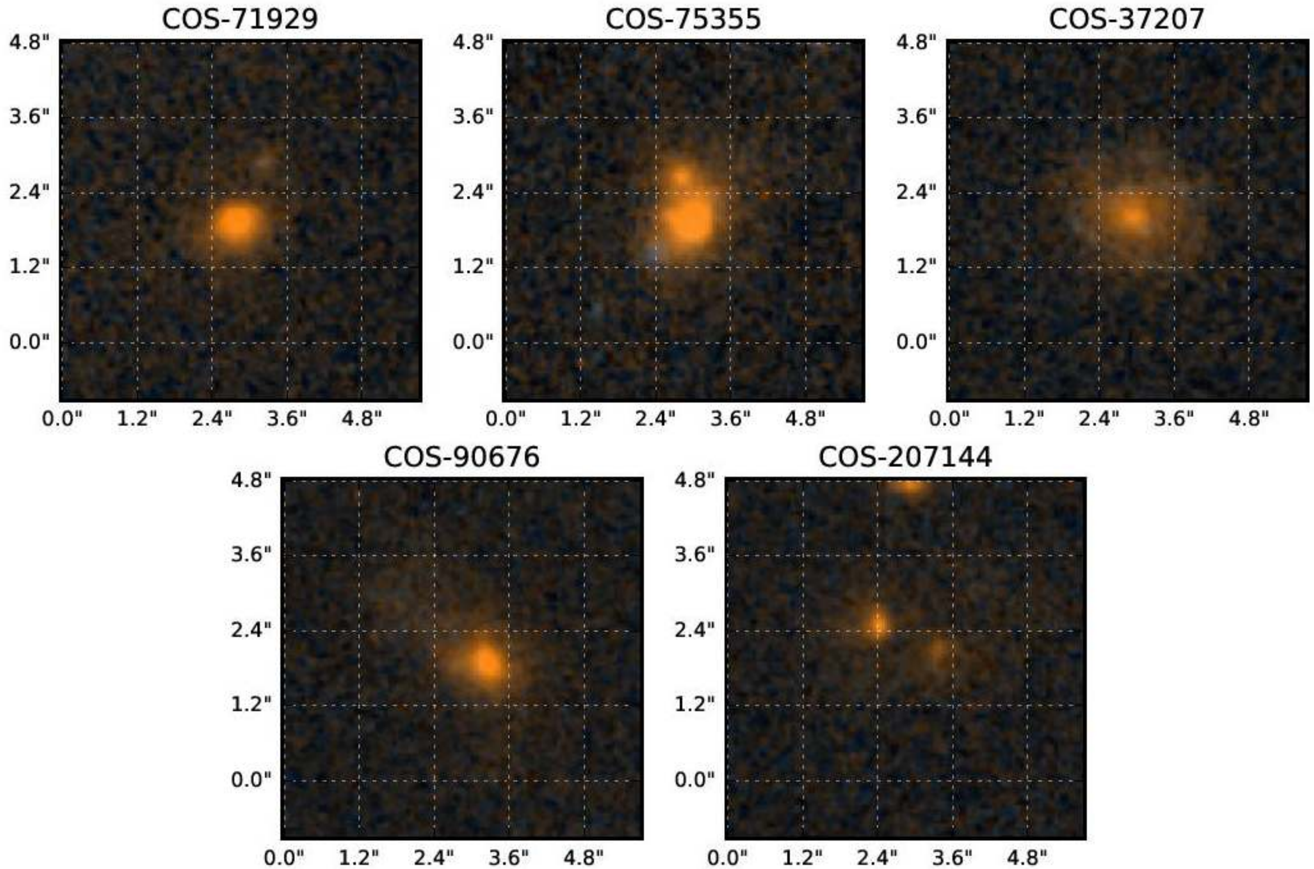
NEAR-INFRARED SPECTROSCOPY OF 5 ULTRA-MASSIVE GALAXIES AT $1.7 < z < 2.7$

ERIN KADO-FONG [1], DANILO MARCHESINI[1], Z. CEMILE MARSAN[1], ADAM MUZZIN[2], RYAN QUADRI[3], GABRIEL BRAMMER[4], RACHEL BEZANSON[5], IVO LABBÉ[6], BRITT LUNDGREN[7], GREGORY RUDNICK[8], MAURO STEFANON[6], TOMER TAL[9], DAVID WAKE[10,11], RIK WILLIAMS[12], KATHERINE WHITAKER[13,14,15], PIETER VAN DOKKUM[16]

(Dated: February 16, 2017)

Вот личики галактик по данным HST



А вот результаты инфракрасной спектроскопии на Gemini:

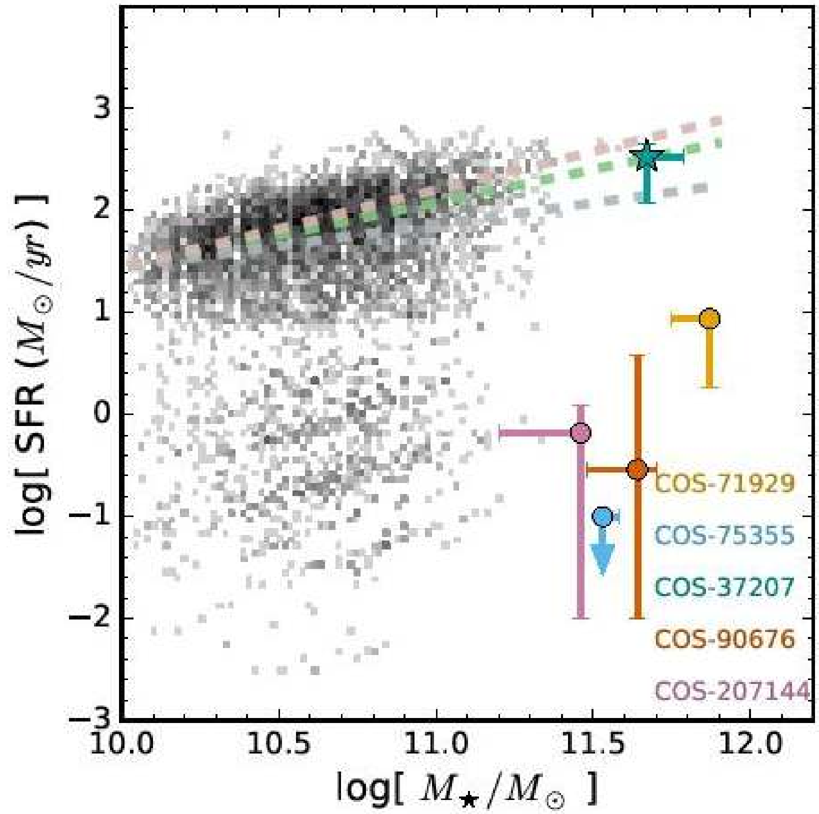


Figure 7. Stellar mass versus star formation rate for the sample (colored points) and the mass-complete UltraVISTA catalog in the range of $1.7 < z < 2.7$. The average star-forming main sequence from Whitaker et al. (2014) for the redshift range in question is shown by the green dashed line.