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Dynamical signature of a stellar bulge in a quasar host galaxy at $z \simeq 6$

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Квазар на z=6

We perform a dynamical decomposition of the rotation curve of SDSS J231038.88+185519.7 (hereafter J2310) at $z = 6.0031$ (Tripodi et al. 2022; Wang et al. 2013), based on high-resolution ALMA observations. J2310 was firstly identified as a quasi-stellar object (QSO) in SDSS (Jiang et al. 2006; Wang et al. 2013) and is one of the most luminous QSOs known in both optical and far-infrared bands, having a bolometric luminosity $L_{\rm bol} = 9.3 \times 10^{13}$ L$_\odot$.

Bischetti et al. (2022) report evidence for an AGN-driven ionised gas wind traced by ultra-violet (UV) broad absorption lines. The host galaxy is characterised by a star formation rate (SFR) in the range ~1200-2400 M$_\odot$ yr^{-1} (Shao et al. 2019; Tripodi et al. 2022), occurring in a regularly rotating gaseous disc, which does not show evidences of interactions or mergers.

Tripodi et al. (2022) present a tilted-ring modelling of the [CII] emission resulting in a flat rotation curve, and derive a disc inclination $i \simeq 25°$ and a dynamical mass $M_{\rm dyn} = 5.2^{+2.3}_{-3.2} \times 10^{10}$ M$_\odot$. They interpret the high velocities seen near the galactic centre as due to a [CII] outflow. An alternative possible explanation for the high-velocity [CII] emission is fast rotation due to the presence of a central mass concentration. In this study, we

Предыдущий заход

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Astronomy & Astrophysics

Black hole and host galaxy growth in an isolated $z \sim 6$ QSO observed with ALMA

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Карта в континууме пыли с разрешением 0.15 сек. Дуги (900пк)

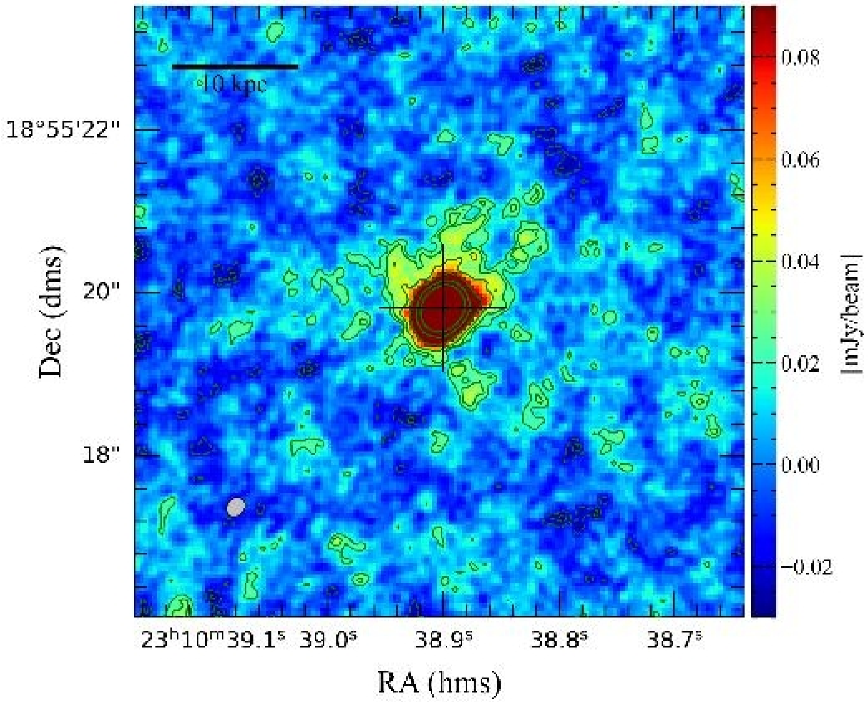
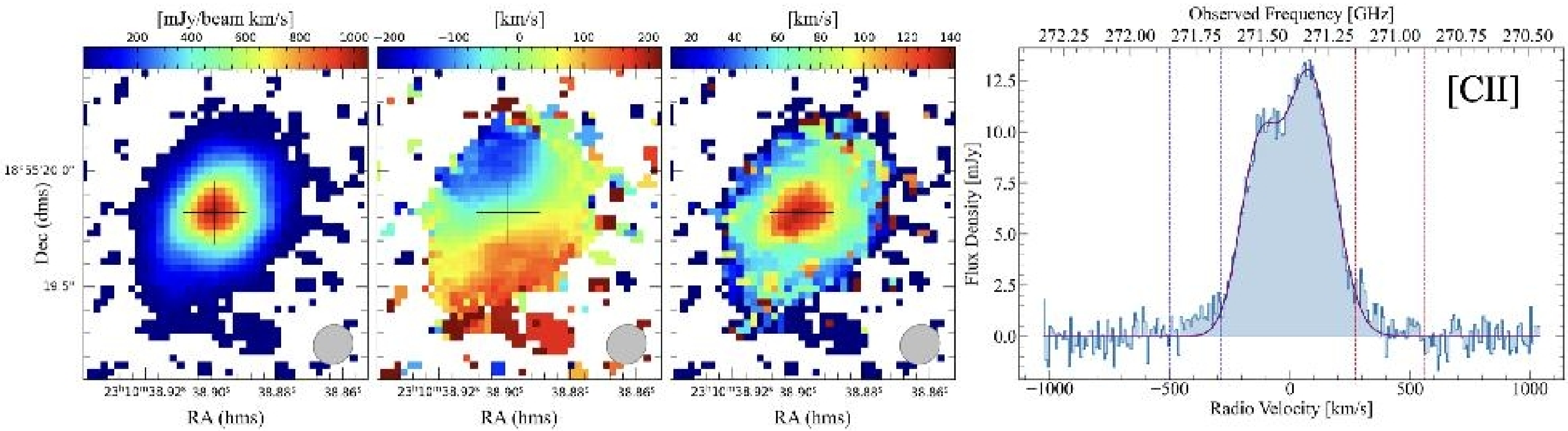


Fig. 1. 260 GHz dust continuum map of QSO J2310+1855 (levels −4, −3, −2, 2, 3, 5, 10, 25, and 50σ, σ = 9.15 μJy beam^{-1}). The clean beam (0.26 × 0.21 arcsec^2) is indicated in the lower left corner of the diagram. The cross indicates the position of the continuum peak.

Эмиссионная линия [CII]: карта, скорость, дисперсия скоростей



Плоская кривая вращения, если отрезать крылья +/- 300 км/с

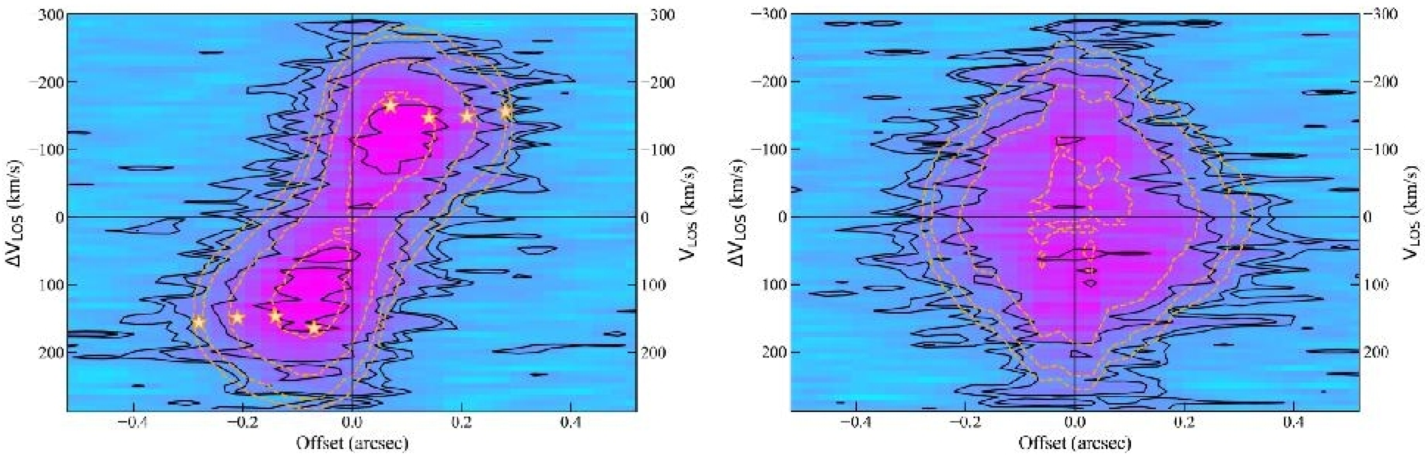
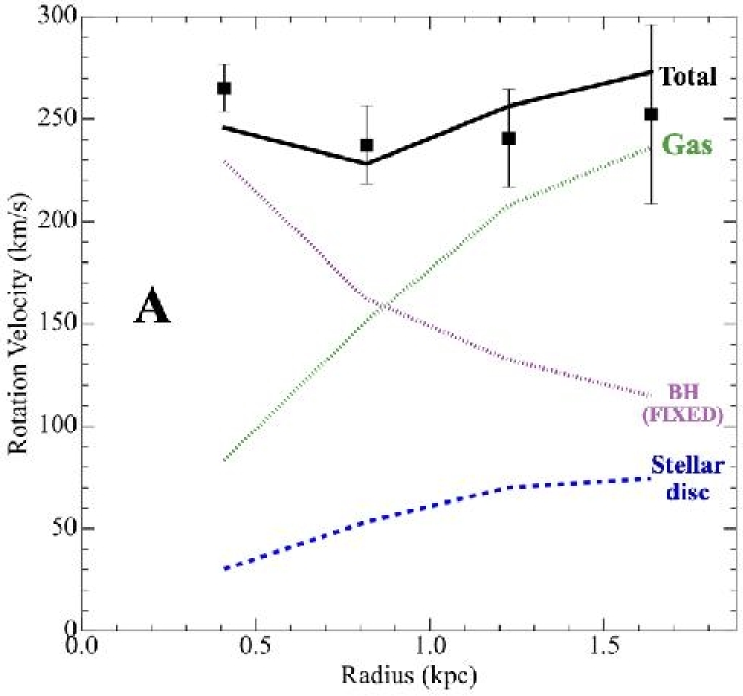


Fig. 1: PV diagrams of the [CII] emission line along the kinematic major axis (left panel) and kinematic minor axis (right panel), performed with ^{3D}Barolo. Contours are at 2, 3, 6, and 12σ, with σ = 0.22 mJy/beam, for the data (solid black lines) and the best-fit model (dashed orange lines). Yellow stars show the projected rotation curve modelled by ^{3D}Barolo .

Декомпозиция кривой вращения



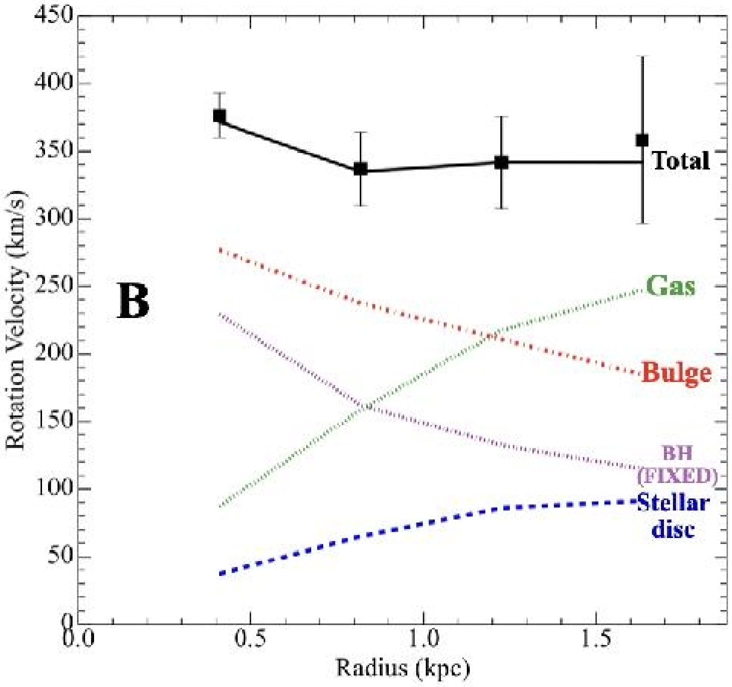


Table 2: MCMC results for the mass model B.

Parameter	Best-fitting values
i [°]	26 ± 4
$M_{gas}[10^{10}\ M_\odot]$	4.26 ± 0.97
$M_{*disc}[10^{10}\ M_\odot]$	$0.34^{+0.43}_{-0.55}$
$M_{bulge}[10^{10}\ M_\odot]$	$1.74^{+1.04}_{-1.17}$
$M_{BH}[10^{10}\ M_\odot]$	0.5 (Fixed)

Сравнение со шкалирующими зависимостями

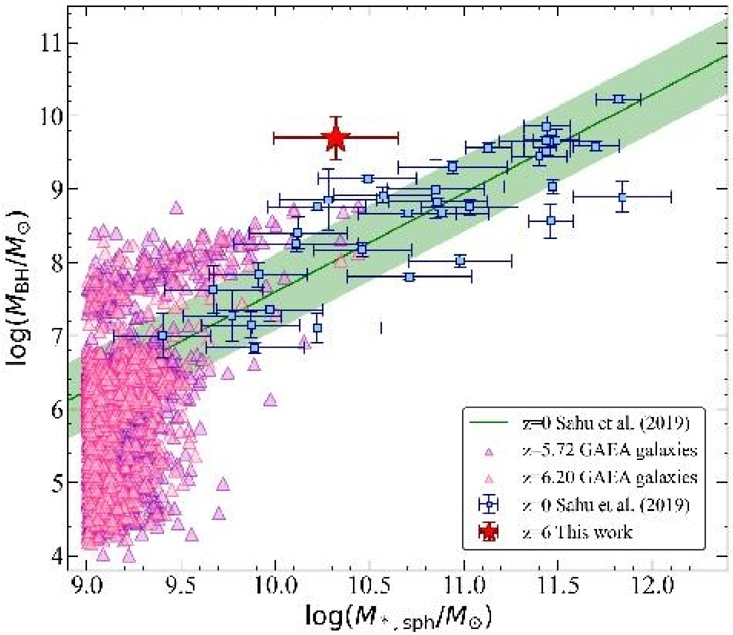


Fig. 3: Black hole mass vs. spheroid stellar mass. Comparison between the $z = 0$ sample of early type galaxies from Sahu et al. (2019) (blue squares) and our results for the $z = 6$ QSO J2310 (red star). The green line is the best-fitting relation for the $z = 0$ sample with its scatter (green shadowed region) taken from Sahu et al. (2019). The purple and pink triangles are respectively the $z = 5.72$ and $z = 6.20$ galaxies modelled by the GAEA-F06 run (Fontanot et al. 2020).

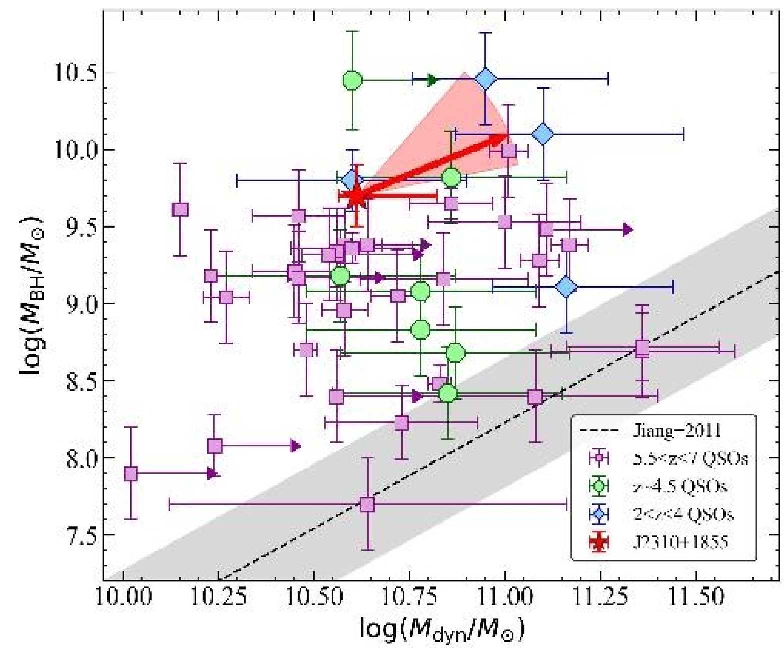


Fig. 10. BH mass as a function of the dynamical mass for J2310+1855 (red star), compared with WISSH QSOs at $z \sim 2$–4 (blue diamonds, from Bischetti et al. 2021), and luminous $z \sim 4$–7 QSOs (green dots and violet squares, from Venemans et al. 2016, 2017; Willott et al. 2013, 2015, 2017; Kimball et al. 2015; Trakhtenbrot et al. 2017; Feruglio et al. 2018; Mortlock et al. 2011; De Rosa et al. 2014; Kashikawa et al. 2015; Neeleman et al. 2021). Jiang et al. (2011) used bulge masses, while all the other dynamical masses refer to the gas disk component.

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Обсуждение

that the BH of J2310 evolves into one of the most massive BH at $z = 0$ ($M_{\rm BH} \simeq 2\times10^{10}$ $M_\odot$), it can grow in mass by only a factor of 4 during ~13 Gyr, while the bulge should grow by a factor of ~40 to reach a mass around $10^{11.8} M_\odot$ at $z \simeq 0$. This suggest an asynchronous growth between SMBH and bulges. Moreover, the available molecular gas in J3210 is estimate to be $\sim 4\times10^{10}$ $M_\odot$. To reach a stellar mass of $\sim 10^{11.8}$ $M_\odot$ at $z \simeq 0$, the galaxy needs to accrete a comparable amount of mass (in gas or directly in stars) over ~13 Gyr, giving an average mass accretion rate of ~ 40 $M_\odot$ yr^{-1}. For example, if the galaxy keeps forming stars with SFR $\simeq 10^3$ $M_\odot$ yr^{-1}, a stellar mass of $(5 - 10) \times 10^{11}$ $M_\odot$ can be formed in only 0.5-1.0 Gyr (by $z \simeq 3.5 - 4.0$) but would then require a mass accretion rate comparable to the SFR. In any case, our result seems to highlight the absence of any symbiotic growth between the SMBH and the host galaxy at high redshift; it appears that the SMBH firstly experiences a phase of rapid and intense growth (reaching up to $5\times10^9 M_\odot$ in less than 1 Gyr), followed by the growth of the galaxy.