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On the origin of surprisingly cold gas discs in galaxies at high redshift

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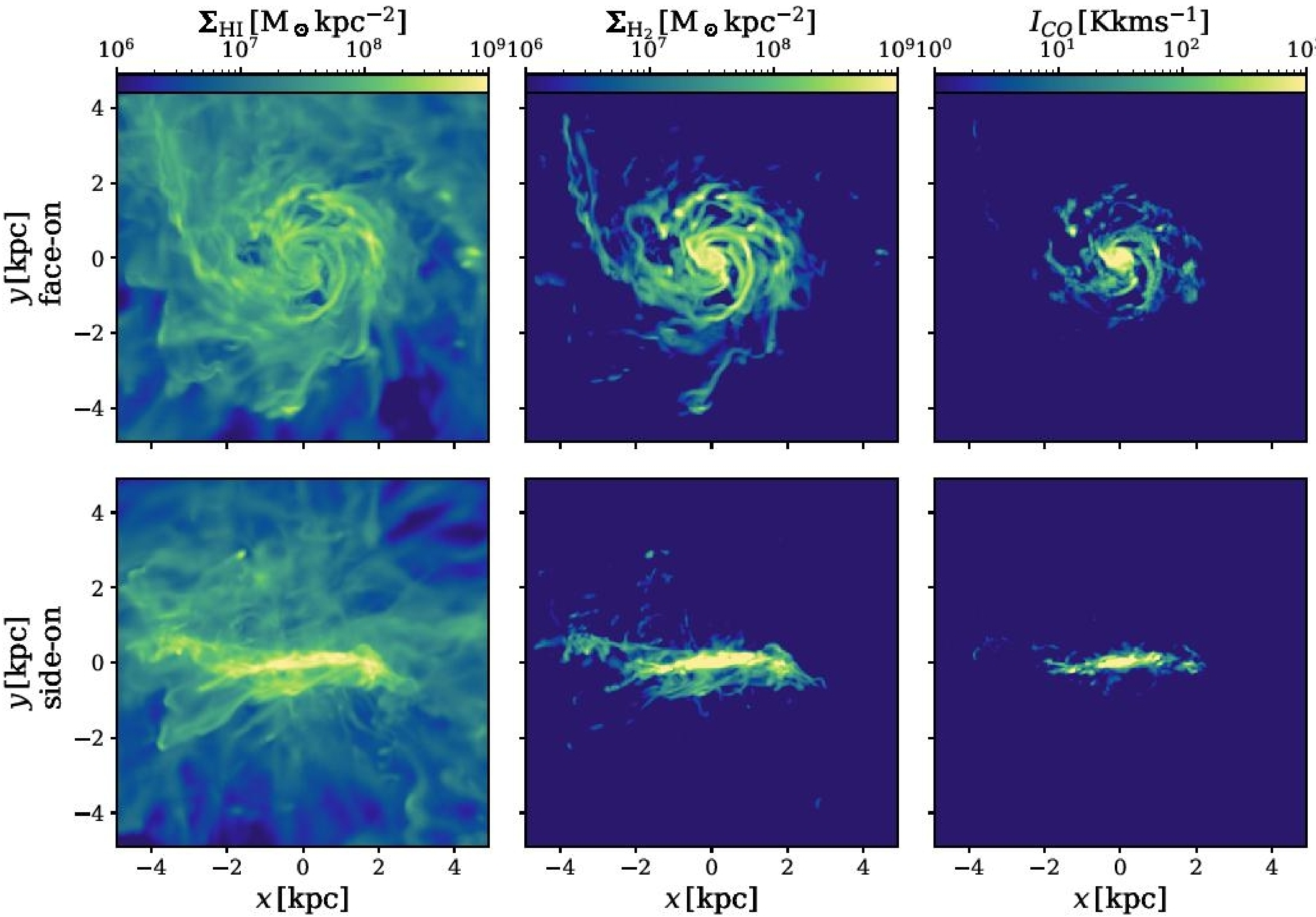
ABSTRACT

We address the puzzling observational indications for very "cold" galactic discs at redshifts $z \gtrsim 3$, an epoch when discs are expected to be highly perturbed. Using a high-resolution cosmological zoom-in simulation, we identify such a cold disc at $z \sim 3.5$, with a rotation velocity to velocity dispersion ratio of $v_\phi/\sigma_r \simeq 5$ for the total gas. It forms as a result of a period of intense accretion of co-planar, co-rotating gas via cold cosmic-web streams. This thin disc survives for ~ 5 orbital periods, after which it is disrupted by mergers and counter-rotating streams, longer but consistent with our estimate that a galaxy of this mass ($M_\star \sim 10^{10} M_\odot$) typically survives merger-driven spin flips for $\sim 2-3$ orbital periods. We find that v_ϕ/σ_r is highly sensitive to the tracer used to perform the kinematic analysis. While it is $v_\phi/\sigma_r \simeq 3.5$ for atomic HI gas, it is $v_\phi/\sigma_r \simeq 8$ for molecular CO and H_2. This reflects the confinement of molecular gas to cold, dense clouds that reside near the disc mid-plane, while the atomic gas is spread into a turbulent and more extended thicker disc.

Есть такая галактика на z=3.5!



Причем молекулярный газ холоднее, чем атомарный

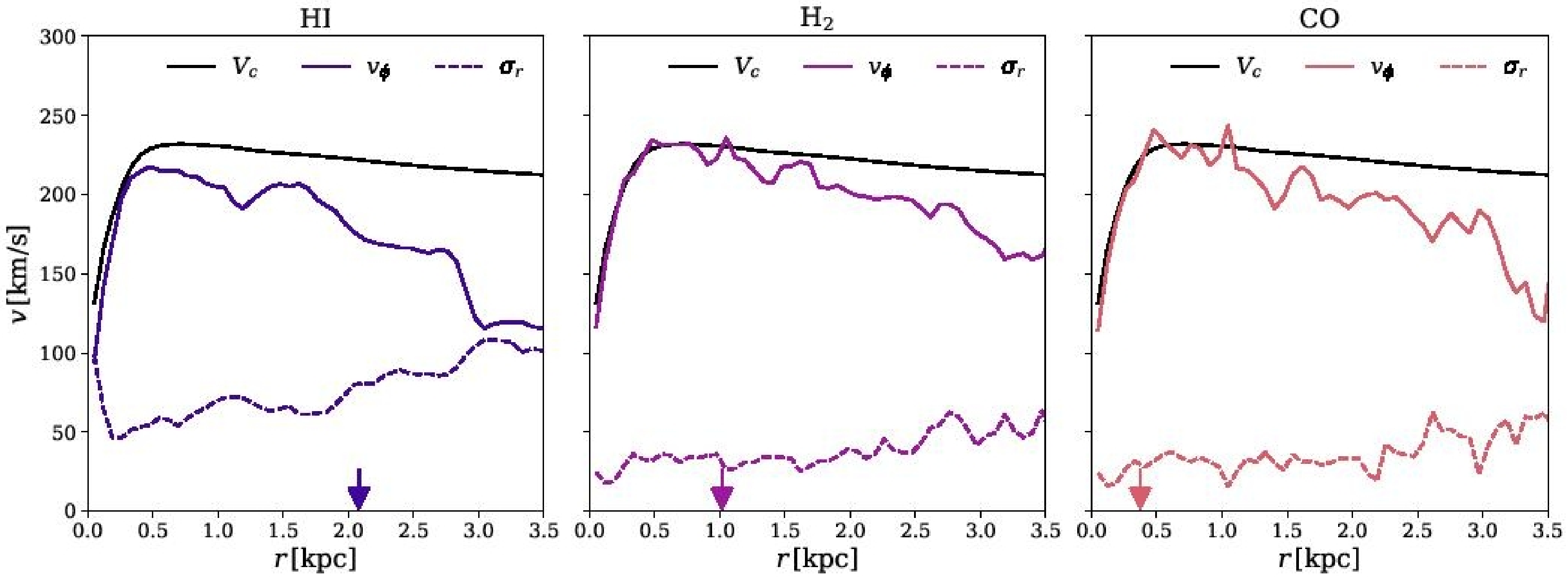


Figure 2. Velocities measured at $z = 3.5$ using the three different tracers HI, H_2 and CO. Shown is the circular velocity V_c together with the rotational velocity v_ϕ and the radial velocity dispersion σ_r. We see that the obtained v_ϕ from H_2 and CO is larger than the one obtained from HI and closer to V_c. Furthermore, the dispersion is smaller and remains mostly constant with a value around $\sigma_r \sim 30\,\mathrm{km\,s^{-1}}$ for H_2 and CO. For HI, the dispersion increases with radius at $r > 2$ kpc, where there is little H_2, and no CO. The relative difference in the obtained values for σ_r is larger than those for v_ϕ. The arrows mark the half-mass radius r_e for each component.

И это короткая стадия: 5 оборотов, или 410 млн лет