First absorption and T_e-based metallicity measured in a GRB host at z = 4.28

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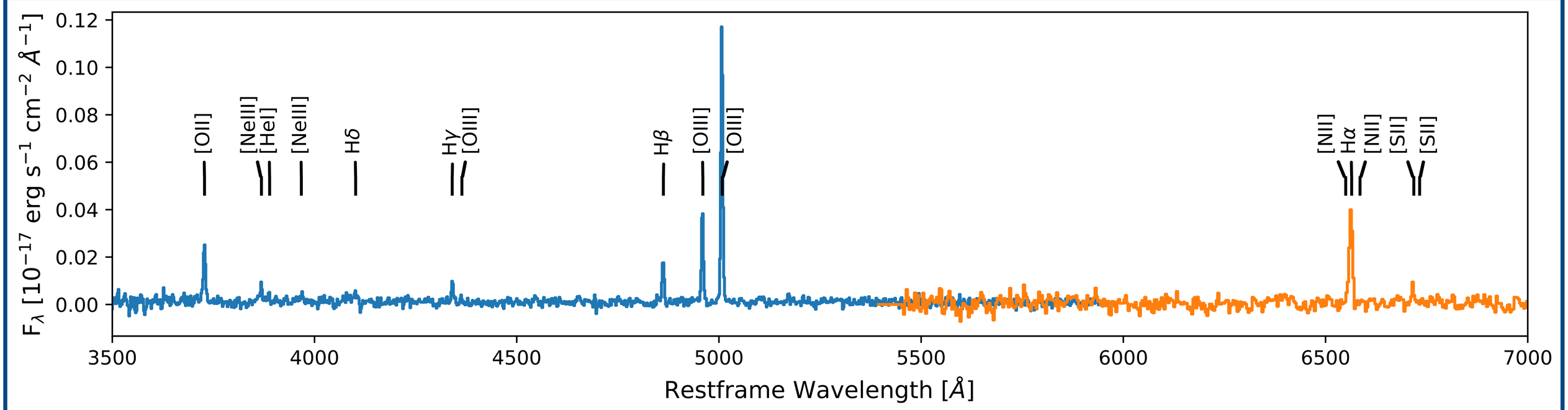

Fig. 1. JWST/NIRSpec spectrum of the host of GRB050505. The detected strong emission lines are marked, as well as the [OIII]λ4363 auroral line

Chemical enrichment is a key aspect of galaxy and stellar evolution. Obtaining accurate gas-phase metallicity measurements is therefore necessary to trace how stars produce metals and recycle them back into the interstellar medium, enriching the gas and successive generations of stars. With the launch of *JWST*, it has now become possible to measure the metallicity of galaxies at higher redshift, which is crucial for understanding galaxy and stellar evolution in the early universe.

We present new JWST/NIRSpec observations of the host of GRB 050505. We calculate the hot ISM metallicity using strong emission lines and the [OIII]λ4363 auroral line to calculate the electron temperature, and re-calculate the cold ISM using absorption lines in the previously published GRB afterglow spectrum. Combining these measurements presents the **first opportunity to bridge the gap between the hot and cold ISM at high redshift.**

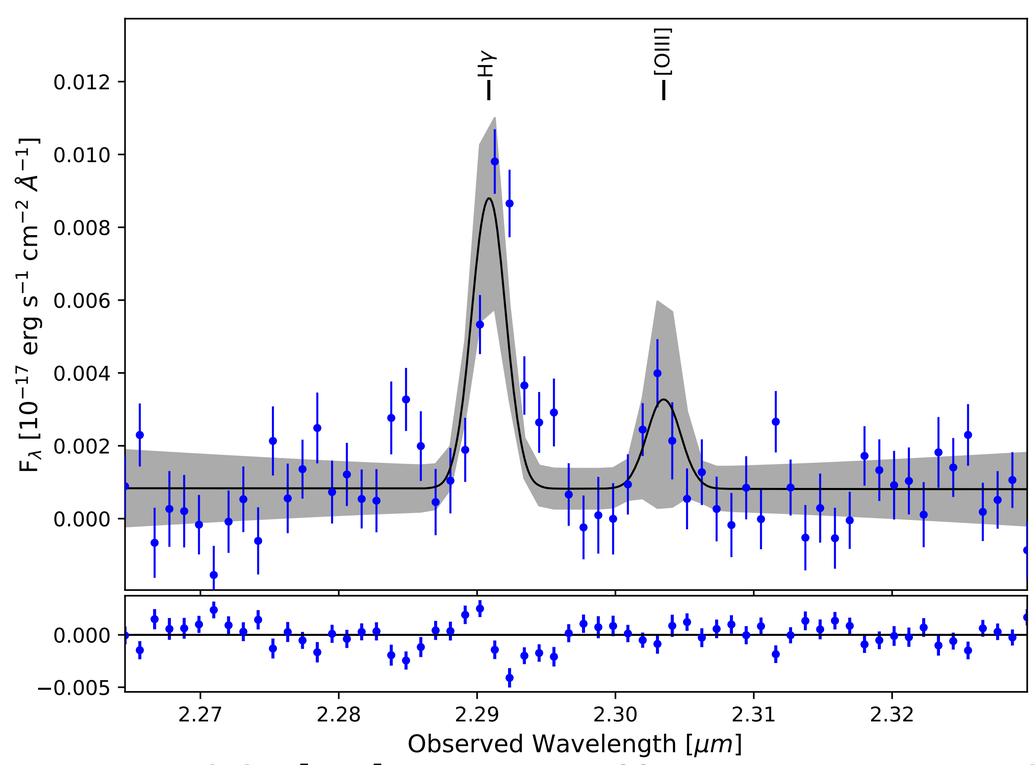

Fig. 2. Hγ and the [OIII]λ4363 auroral line at a consistent redshift to the strong emission lines in Fig. 1. We obtain an electron temperature (Te) of (1.6±0.4)x10^4 K and calculate 12+log(O/H) between 7.81±0.19 and 7.96±0.21, depending on the model.

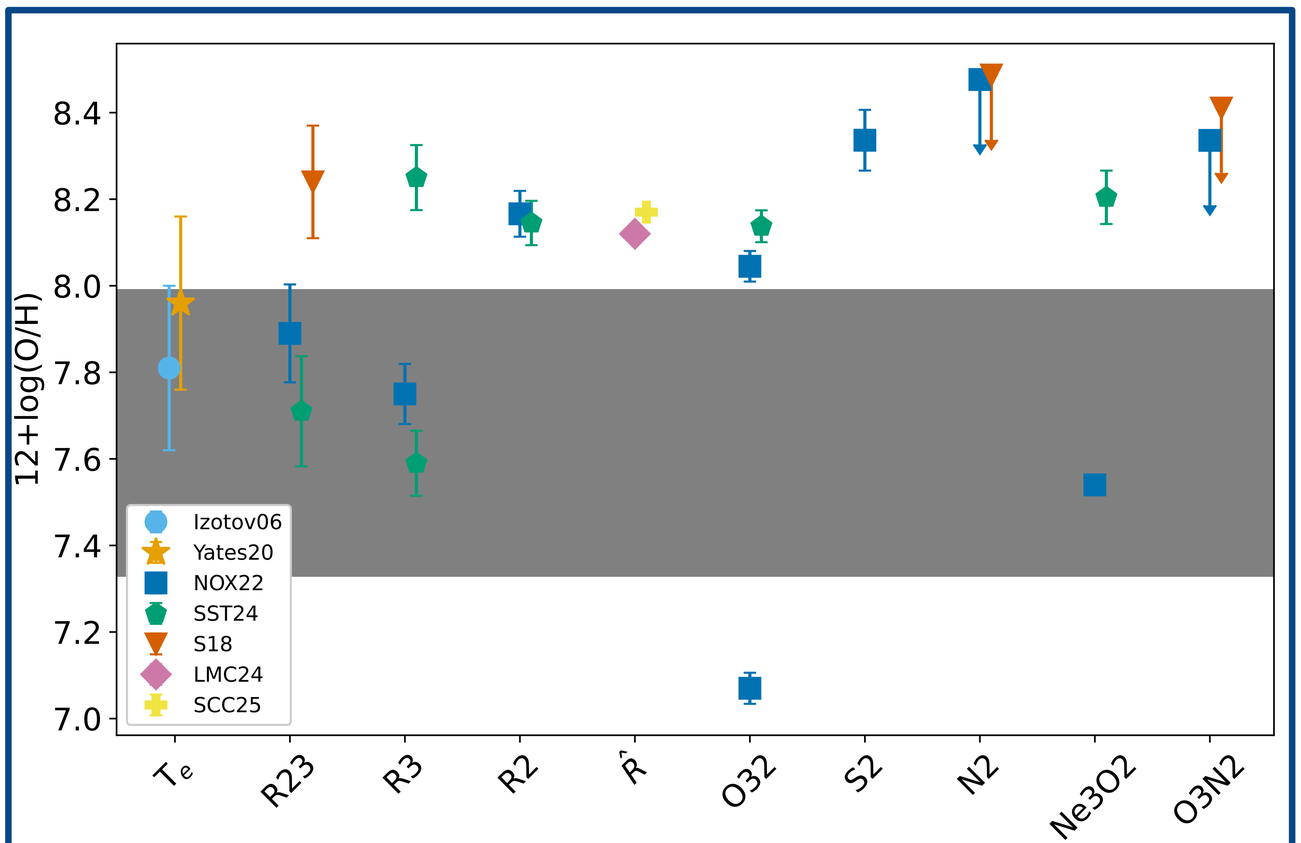

Fig. 4. Comparison of the absorption based metallicity in grey bands, strong emission line diagnostics, marked with different markers and colours for each calibration sample, and the Te-based metallicities on the far left. We can see that the cold gas metallicity and the Te-based metallicity are consistent, while most of the strong line metallicities are not consistent with the absorption based metallicity.

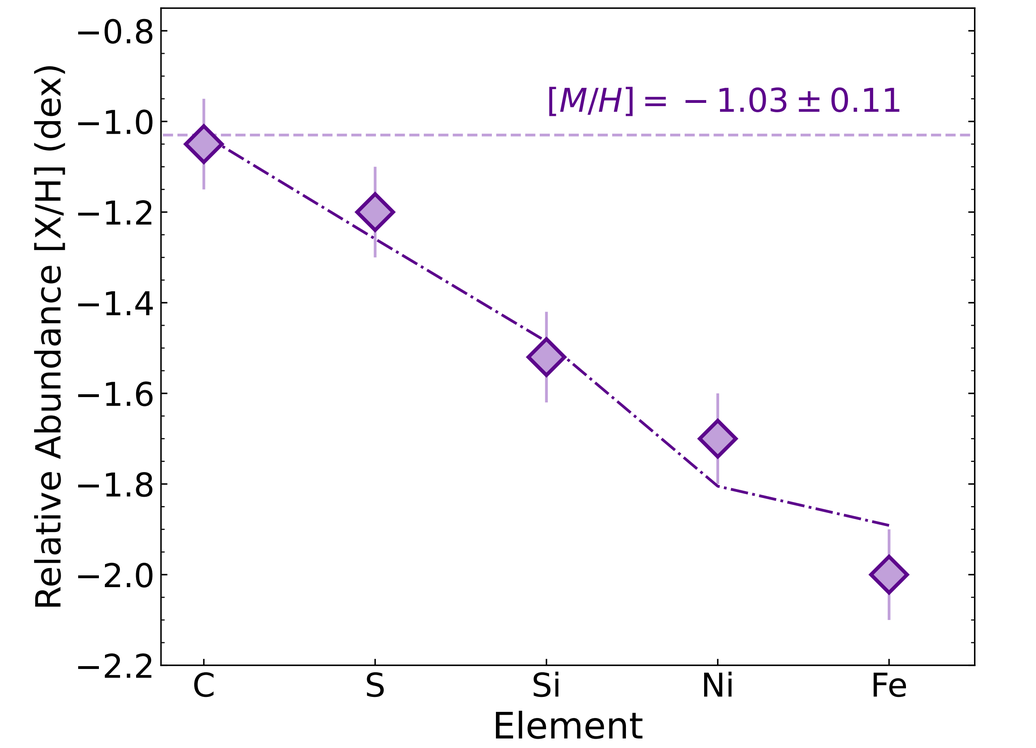

Fig 3. Re-calculation of the absorption based metallicitiy following the procedure from Wiseman et al.,2017, A&A, 607, A107 using the relative abundances from Berger et al.,2006, ApJ, 642, 979 and the detailed depletion pattern from De Cia et al.,2016, A&A, 596, A97.

We conclude that for the host of GRB050505, mixing between the hot and cold gas is efficient along the line of sight to the GRB. We advocate for the use of only strong line relations calibrated on high-z galaxy samples or relations that include the degree of ionisation of the ISM.

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