Draft version April 12, 2023
Typeset using LaTeX default style in AASTeX631

On the discovery claim of a new $z > 7$ quasar

Sarah E. I. Bosman,[1] Frederick B. Davies,[1] and Eduardo Bañados[1]

[1] Max-Planck-Institut für Astronomie
Königstuhl 17, D-69117
Heidelberg, Germany

ABSTRACT

Koptelova & Hwang (2022) (K22) recently claimed a new quasar discovery at $z = 7.46$. After careful consideration of the publicly-available data underlying K22's claim, we find that the observations were contaminated by a moving Solar System object, likely a main-belt asteroid. In the absence of the contaminated photometry, there is no evidence for the nearby, persistent WISE source being a high-redshift object; in fact, a detection of the source in DELS z-band rules out a redshift $z > 7.3$. We present our findings as a cautionary tale of the dangers of passing asteroids for photometric selections.

1. INTRODUCTION

Luminous quasars at the highest redshifts have far-ranging uses in astrophysics and cosmology, from studying reionisation to the origin of supermassive black holes (Fan et al. 2022; Bosman et al. 2022; Eilers et al. 2021). As such, the search for new quasars at the high-redshift frontier, currently at $z \gtrsim 7$, is a very active and competitive field (e.g. Wang et al. 2021).

2. CLAIM OF DISCOVERY A NEW QUASAR AT $Z \simeq 7.5$

Recently, a pre-print was posted on the arXiv server claiming the discovery of a new quasar at $z = 7.46$ (K22). The candidate was initially selected based on survey photometry from WISE (Wright et al. 2010) and UKIDSS+UKIRT (Lawrence et al. 2007). The identification was based on the following criteria:

1. The candidate was detected in the WISE/W1 and WISE/W2 photometric bands, with W2 being brighter;
2. It was (thought to be) brighter in the UKIDSS/J photometric band than in the W1 band, with a reported J-band magnitude of $J = 19.3$ (all magnitudes AB);
3. It was undetected in all Pan-STARRS (Chambers et al. 2016) bands $grizy$.

Indeed, such a large difference between a bright J-band and a non-detection in the z-band, of over 3 magnitudes, would justify the selection of the object as a potential $z > 7$ quasar.

However, after analysing the public UKIRT/UKIDSS data of the candidate, we have uncovered evidence that the J band photometry used by K22 is contaminated by a passing asteroid. The top row of Figure 1 shows that the object centered in the J-band image is offset by about 2" in the Y-band image observed 23 minutes earlier. By extrapolating the object's trajectory, we further located it in the UKIDSS H and K band imaging taken on the previous day about 1'22" away (rightmost two panels of Fig. 1). We obtained flux-weighted centroids for the 4 known positions of the moving object with *SourceExtractor* (Bertin & Arnouts 1996). We input those position-time coordinates into the web-based platform *Find_Orb*[1], which performs orbit reconstruction for Solar System objects. The object's motion is entirely consistent with a heliocentric orbit with a semi-major axis of 2.5 ± 1 au, identifying it as a likely main-belt asteroid. Large uncertainties on orbital elements originate from the short time baseline between the 4 chance observations and prohibit us from accurately extrapolating the motion beyond a few weeks. We are not aware of any other imaging survey which would have serendipitously captured the object around November or December 2008.

Excluding the contaminated photometric frames, the object is undetected in UKIDSS J. However, a WISE source, detected in W1 and W2, is indeed consistent with the location given by K22 (bottom panels of Fig. 1). We examined

[1] https://www.projectpluto.com/find_orb.htm

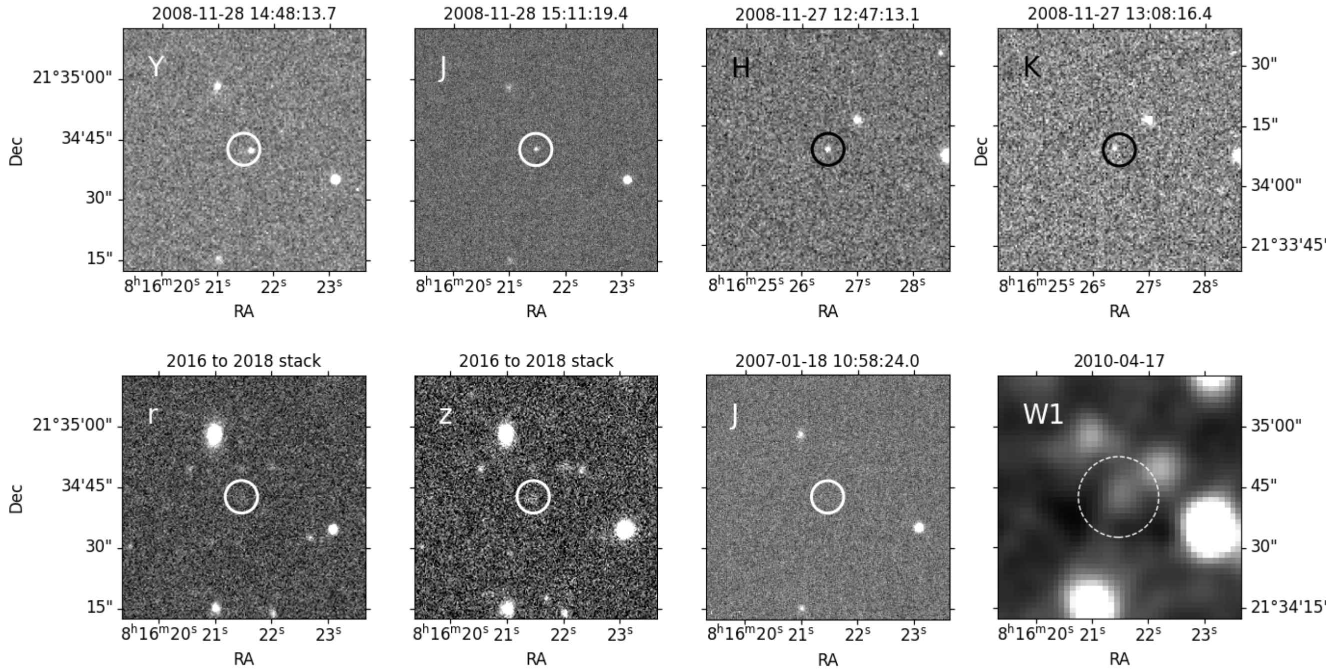

Figure 1. *Top:* Motion of the contaminating asteroid in UKIDSS. The observing epoch is indicated above each panel; the central circle is 8" across. The H and K band images are spatially offset from the J and Y bands by about 1'22" (W1 circle is 20" across). *Bottom*: photometry of the candidate object at times uncontaminated by the asteroid. The object is undetected in the UKIDSS J band; a detection in DELS z band conclusively rules out a redshift $z > 7.3$.

this WISE source in the DESI Legacy Imaging Surveys (DELS; Dey et al. 2019), which provide significantly deeper z-band imaging than both UKIDSS and Pan-STARRS. We find that the WISE source is detected at $> 5\sigma$ in the z band (Fig. 1). A detection in the z-band completely rules out the object being a quasar at $z > 7.3$, since full absorption by the neutral intergalactic medium would be unavoidable at rest-frame wavelengths $\lambda < 1215.67$Å.

As a follow-up to the photometric selection of the candidate, K22 present a spectrum of the object taken with the GNIRS spectrograph (Elias et al. 2006a,b). The timing of the spectroscopic observations mean that the spectrum originates in the persistent WISE source, and are uncontaminated by the asteroid. This spectrum as shown in K22 allegedly shows features confirming the object's nature as a $z = 7.46$ quasar: a break in the continuum at $\lambda \sim 1.1\mu$m, and a Mg II emission line at $\lambda \sim 2.35\mu$m. We reduced the publicly-available raw spectral data with the *PypeIt* spectroscopic reduction package (Prochaska et al. 2020) and can confirm neither of these features. While the WISE object is detected as a faint continuum, light is clearly present at $\lambda < 0.95\mu$m: there is no sharp spectral break. This is in agreement with the detection of the object in DELS z-band. We do not see a clear emission-line feature at $\lambda \sim 2.35\mu$m, nor any other wavelength.

REFERENCES

Bertin, E., & Arnouts, S. 1996, A&AS, 117, 393

Bosman, S. E. I., Davies, F. B., Becker, G. D., et al. 2022, MNRAS, 514, 55, doi: 10.1093/mnras/stac1046

Chambers, K. C., Magnier, E. A., Metcalfe, N., et al. 2016, arXiv e-prints, arXiv:1612.05560, doi: 10.48550/arXiv.1612.05560

Dey, A., Schlegel, D. J., Lang, D., et al. 2019, AJ, 157, 168, doi: 10.3847/1538-3881/ab089d

Eilers, A.-C., Hennawi, J. F., Davies, F. B., & Simcoe, R. A. 2021, ApJ, 917, 38, doi: 10.3847/1538-4357/ac0a76

Elias, J. H., Joyce, R. R., Liang, M., et al. 2006a, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, Vol. 6269, Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, ed. I. S. McLean & M. Iye, 62694C, doi: 10.1117/12.671817

Elias, J. H., Rodgers, B., Joyce, R. R., et al. 2006b, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, Vol. 6269, Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, ed. I. S. McLean & M. Iye, 626914, doi: 10.1117/12.671765

Fan, X., Banados, E., & Simcoe, R. A. 2022, arXiv e-prints, arXiv:2212.06907, doi: 10.48550/arXiv.2212.06907

Koptelova, E., & Hwang, C.-Y. 2022, arXiv e-prints, arXiv:2212.05862, doi: 10.48550/arXiv.2212.05862

Lawrence, A., Warren, S. J., Almaini, O., et al. 2007, MNRAS, 379, 1599, doi: 10.1111/j.1365-2966.2007.12040.x

Prochaska, J., Hennawi, J., Westfall, K., et al. 2020, The Journal of Open Source Software, 5, 2308, doi: 10.21105/joss.02308

Wang, F., Yang, J., Fan, X., et al. 2021, ApJL, 907, L1, doi: 10.3847/2041-8213/abd8c6

Wright, E. L., Eisenhardt, P. R. M., Mainzer, A. K., et al. 2010, AJ, 140, 1868, doi: 10.1088/0004-6256/140/6/1868