Highest Redshift Detection of 21-cm Hydrogen in a Gravitational Lens

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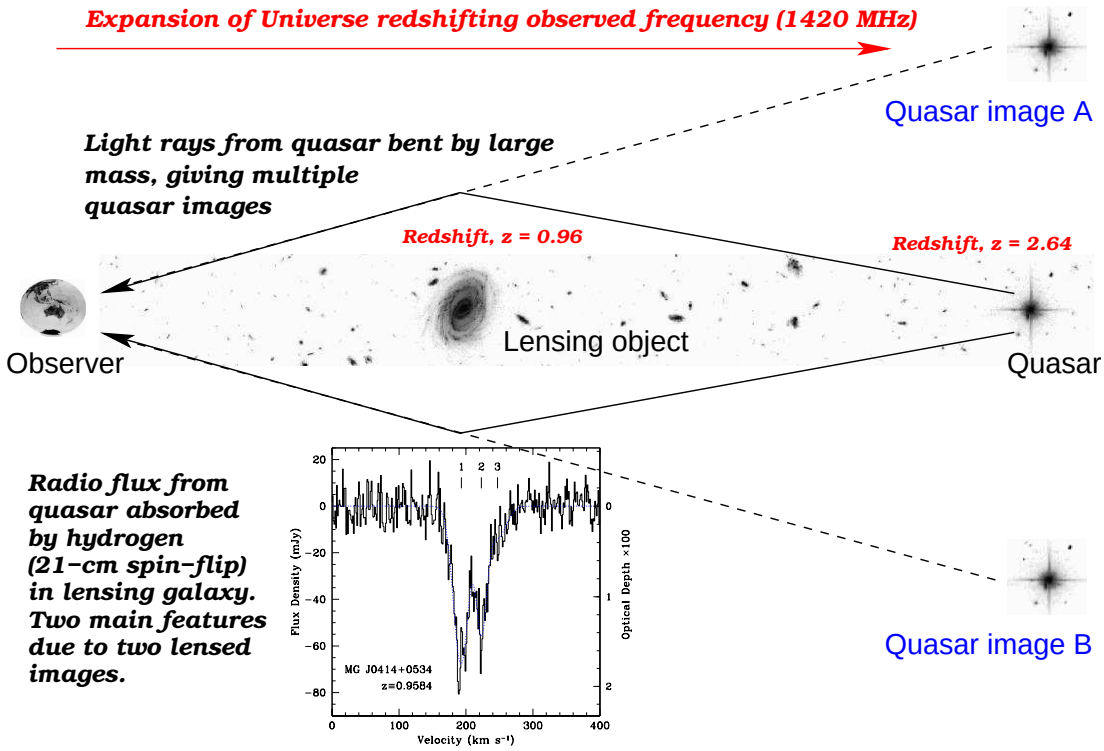
As part of our spectral-scanning survey towards optically dim radio sources with the USA's Green Bank Telescope (see last year's *Searching for Invisible Galaxies in the Distant Universe*), we have detected absorption due to the 21-cm spin-flip transition of neutral hydrogen in the $z = 0.96$ gravitational lens towards the $z = 2.64$ quasar MG J0414+0534 (see figure). After three decades of high redshift 21-cm searches (not by us!), this is the fourth only gravitational lens in which neutral hydrogen has been detected, as well as being the highest redshift detection to date (corresponding to a look-back time of 7.6 billion years).

Being very dim at optical wavelengths, the object responsible for the lensing of the quasar light is very difficult to actually see. Using the two main absorption features (see figure), which correspond to the two main lens images[1], however, we estimate a dynamical mass in excess of 100 billion solar masses (2×10^{41} kilogrammes), consistent with the object being a large spiral galaxy.



It is this very dimness which led us to targetting this object, since the interstellar dust which protects molecules against the intense ambient ultra-violet radiation, also dims and reddens the appearance of the background quasar (think of a sunset, where the sunlight passes through a larger column of the atmosphere). With an optical–near-IR colour of $V - K = 10.26$, this is one of the reddest objects known[2]. Despite this, unlike the three other HI absorbing lenses, the hydroxyl (OH) radical has not been detected in this case, to limits over ten times better than those expected. We therefore suggest that the reddening is in fact not occurring in the intervening lens, but in the galaxy hosting the quasar itself, which also exhibits H I absorption, five times stronger than that reported here. In order to investigate this, we have obtained further telescope time to search for the molecular gas we now expect to be located in the quasar host.

[1] See Fig. 2 of Curran et al., 2007, Monthly Notices of the Royal Astronomical Society 382, 11

[2] cf. Fig. 2 in last year's report