

Ancient Light

Quasar PS1 J161737+595020

Ancient Light

Imaging a quasar without a telescope

Nikon D7500
300mm f/4 lens
256x30s exp

Redshift $z = 4.315$
Light-travel time = 12.4 billion years
Distance now = 24.6 billion light-years

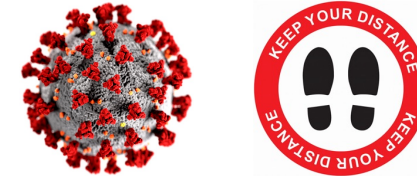
iOptron SkyTracker

Dr Steve Barrett

HLCO 9 Feb 2023

Lockdown Challenge

In early 2020 life as we knew it changed. Life in lockdown.



Stephen Hawking: "Remember to look up at the stars and not down at your feet. Try to make sense of what you see and wonder about what makes the universe exist."

The Challenge

The Universe is vast and ancient. Large telescope have imaged galaxies that are billions of light-years distant.

Is it possible to capture an image of one of these very remote objects **without** a telescope?

(Spoiler alert: Yes, it is)

Quasar Survey

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The Extremely Luminous Quasar Survey in the Pan-STARRS 1 Footprint (PS-ELQS)

Jan-Torge Schindler^{1,2}, Xiaohui Fan¹, Xue-Hui Huang¹, Minghao Yue¹, Jinyi Yang¹, Patrick B. Hall³,
Lukas Wenzl², Allison Hughes¹, Katrina C. Lake¹, and Jon M. Rees⁴

A **quasar** is the nucleus of a galaxy that emits enough light to be seen at a distance of billions of light-years

parent sample of 74,318 sources. After exclusion of known sources and rejection of candidates with unreliable photometry, we have taken optical identification spectra for 290 of our 334 good PS-ELQS candidates. We report the discovery of 190 new $z \geq 2.8$ quasars and an additional 28 quasars at lower redshifts. A total of 44 good PS-ELQS candidates remain unobserved. Including all known quasars at $z \geq 2.8$, our quasar selection method has a selection efficiency of at least 77%. At lower declinations, $-30 \leq \text{decl.} \leq 0$, we approximately treble the known population of extremely luminous quasars. We provide the PS-ELQS quasar catalog with a total of 592 luminous quasars ($m_i \leq 18.5$, $z \geq 2.8$). This unique sample will not only be able to provide constraints on the volume density and quasar clustering of extremely luminous quasars, but also offers valuable targets for studies of the intergalactic medium.

Key words: galaxies: nuclei – quasars: general

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Quasar – Artist's Impression



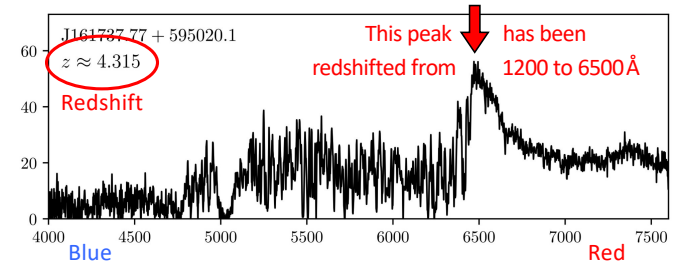
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The Extremely Luminous Quasar Survey in the Pan-STARRS 1 Footprint (PS-ELQS)



A redshift of 4.315 means that this quasar is VERY remote!

Camera and Tracker

iOptron
SkyTracker

The tracker rotates the camera at 1 rev/day to follow the stars



Nikon D7500
300 mm f/4 lens

Camera and Lens

Note: The Nikon D7500 digital SLR camera and 300 mm f/4 lens are the camera equipment that I use for wildlife photography – they are not 'customised' or 'modified' for astrophotography.

If this camera and lens can be used to photograph zebras ...



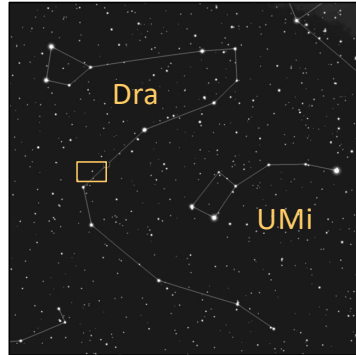
...can they also be used to photograph a quasar?

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Location in Draco

The quasar is located in the constellation of Draco.

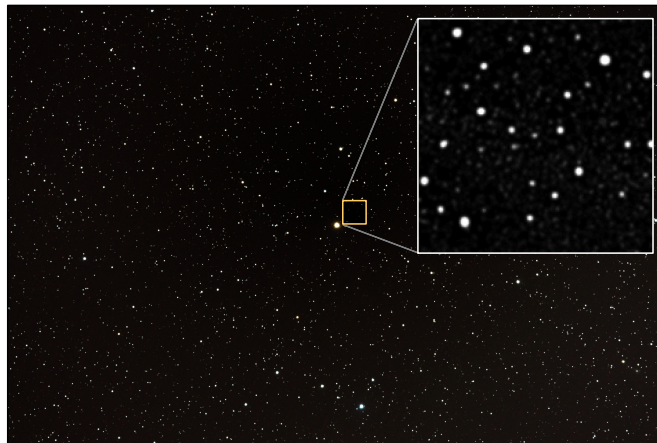
The rectangle shows the field of view of the 300mm lens.



Expose For 2 Hours

Rather than take one 2-hour-long exposure
lots of shorter exposures were added together

The Quasar



The Quasar

Just a pixel
of the
20 Megapixel
image

Most of
the light
from the
quasar is
focussed
into one
pixel

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Just a Pixel?

Technical aside:

What resolution can we expect from the lens and the camera?

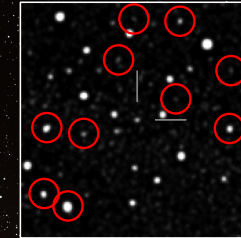
	$\mu\text{radians}$	arcsec
300mm f/4 lens	9	< 2"
Nikon D7500 DSLR	15	3"

For comparison, at a distance of a few billion light-years the Milky Way would appear to have a diameter of $\sim 30 \mu\text{rad}$ or 6".

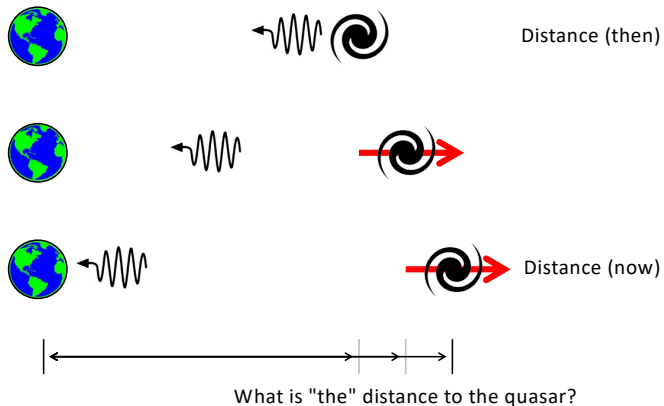
Barrett Deep Field

This 8' x 8' crop contains at least 10 galaxies ...

... so the full image may have captured about 7000 galaxies.

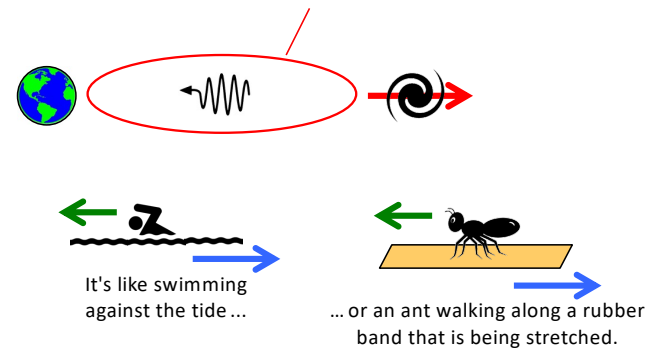


"The" Distance

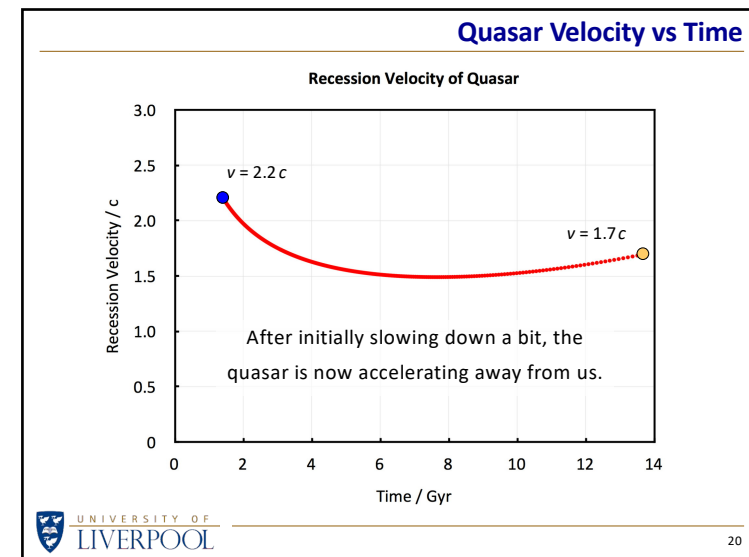
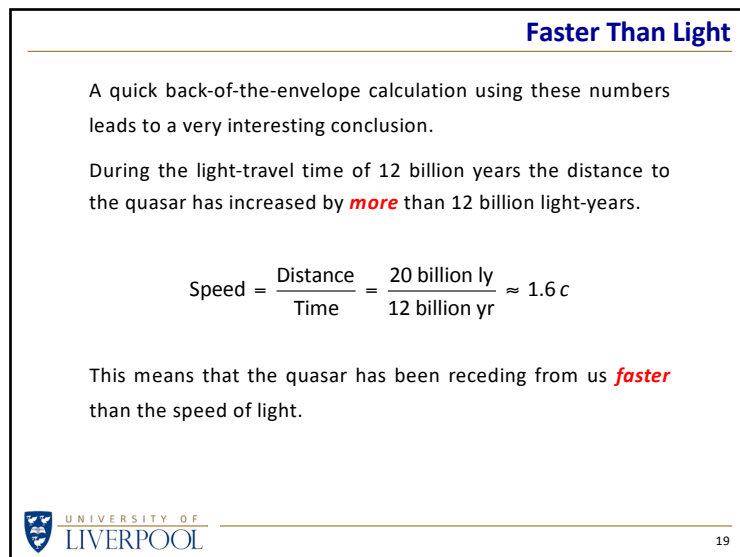
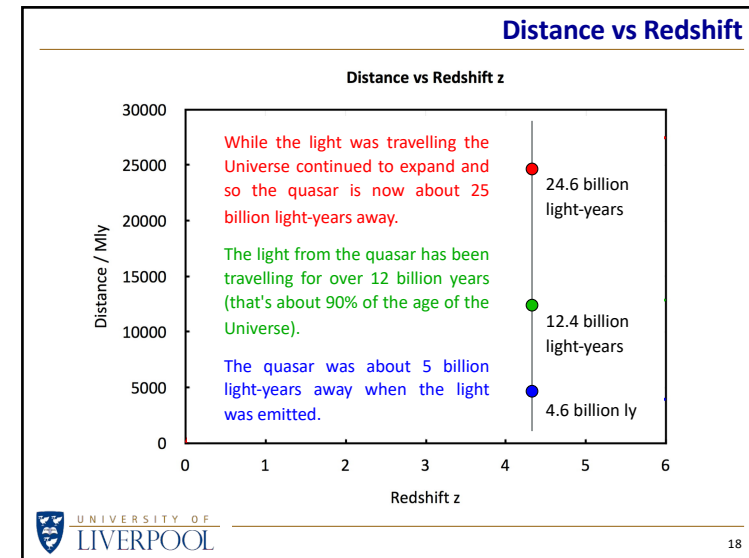
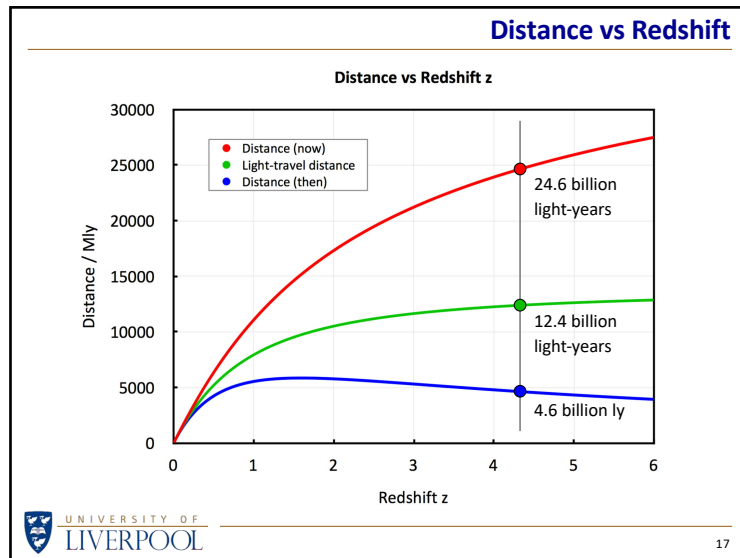


"The" Distance

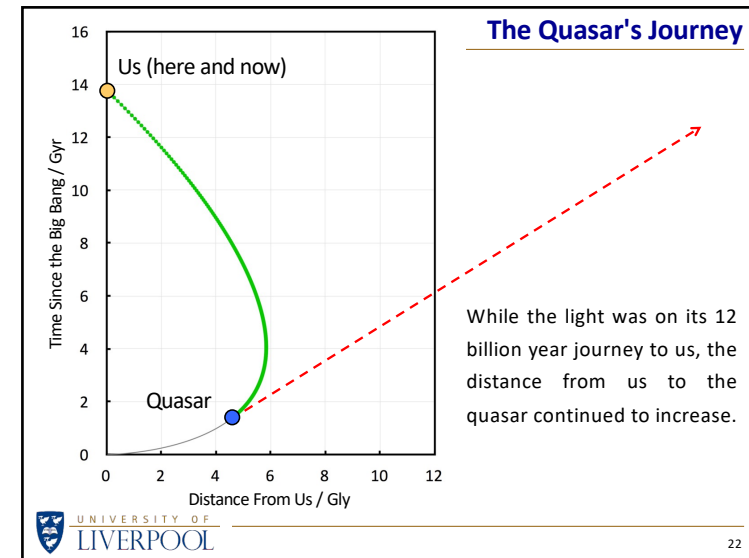
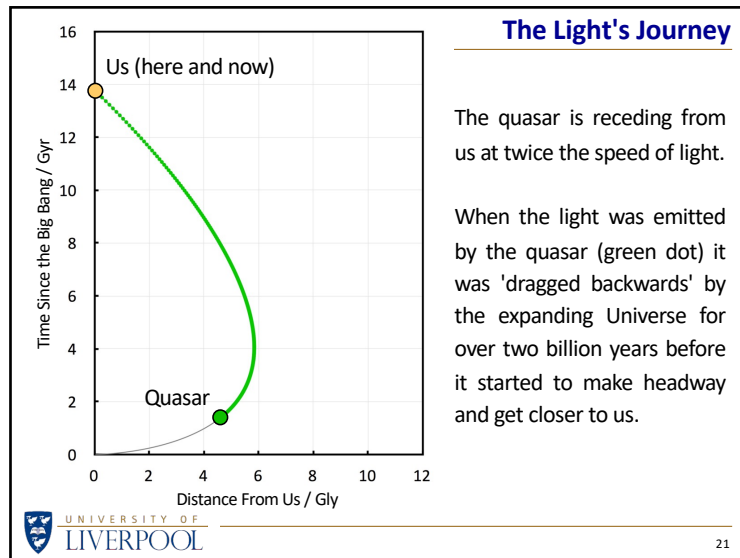
What distance has the light travelled?
That's tricky: Space continues to expand as the light travels.



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The light was emitted by the quasar 1.4 billion years after the Big Bang.

It had already been travelling for nearly 8 billion years when the Sun and the Earth were born. It continued on its journey through the void for another 4.5 billion years.

Life evolved on Earth. The light travelled on.

Dinosaurs came and went. The light travelled on.

In the last million years of its journey it arrived at the edge of our Milky Way galaxy, crossed a few spiral arms, and entered the Solar System.

In its last few hours it finally arrived at Earth, travelled through the atmosphere in a fraction of a second, hurtled towards England, dodged a few clouds, and entered the lens and hit the camera sensor.

Just a pixel in the image ... but what a journey!

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23

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www.liverpool.ac.uk/~sdb/Talks

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