A Dual Red QSO at Cosmic Noon

HST STIS Spectroscopic Analysis

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Every large galaxy in the Universe appears to host a supermassive black hole (SMBH) at its gravitational center.

An Active Galactic Nucleus (AGN):

- ★ Compact area at the innermost part of a galaxy
- ★ Vast luminosity over some or all of the electromagnetic spectrum in comparison with the rest of the galaxy, most luminous source in universe
- ★ An AGN powered by a SMBH is what we call a quasar or quasi-stellar object (QSO)

Illustration of simulated Webb images of quasar and galaxy surrounding quasar.
Credit: NASA, ESA, CSA, Joseph Olmsted (STScI) (2021)

Motivating Questions:

How do these black holes get so big?

★ From millions to billions solar masses

&

How do they relate to their host galaxies?

★ Trigger star formation

★ Quench it by expelling extra gas

What do we already know?

★ Cosmological structures of the universe, that predict how galaxies and galaxy clusters form, require mergers between galaxies as a **key** ingredient.

★ With the Laser Interferometer Gravitational-Wave Observatory (LIGO) we have evidence of low-mass black hole mergers

★ *Our understanding of SMBH mergers is still poor*

Stephan's Quintet NASA, ESA, CSA, and STScI

Serendipitous Discovery:

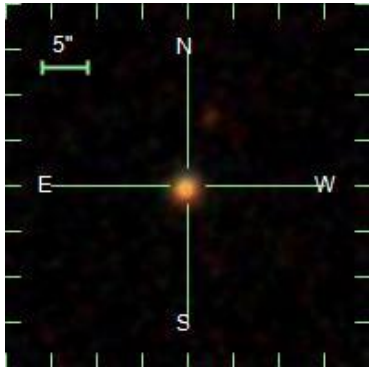
★ An imaging program with *Hubble* Space Telescope was observing the host galaxies of sample W2M of red quasars and found that W2M J122016.9+112627.091, at z = 1.872*, **appeared as two closely separated point sources**

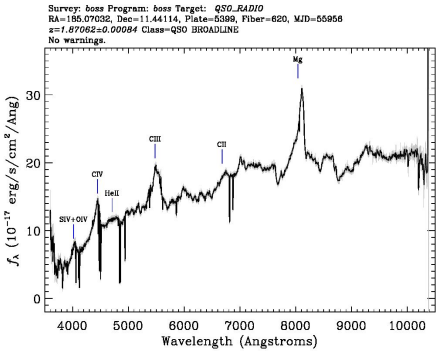
★ *at a redshift that is in the era known as “cosmic noon" where most of the black hole and stellar mass growth occurred.
(Cycle 24, PID 14706, PI Glikman) (Glikman et al. 2021)

To verify that both sources are quasars, requires two spectra: one for each source.

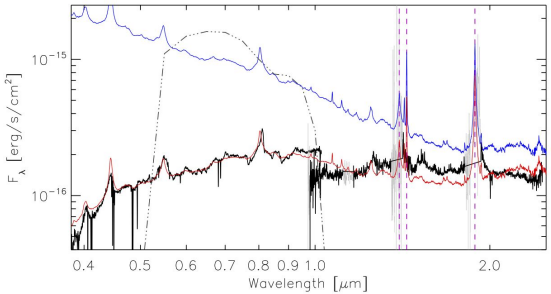
– Requires observations with the HST

★ **In March 2022, Professor Glikman obtained a spectrum of this candidate dual quasar with the STIS spectrograph on HST.**



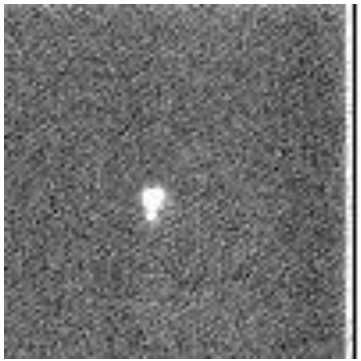


Original SDSS boss Survey of J122016.9+112627.091



From the imaging program with HST:

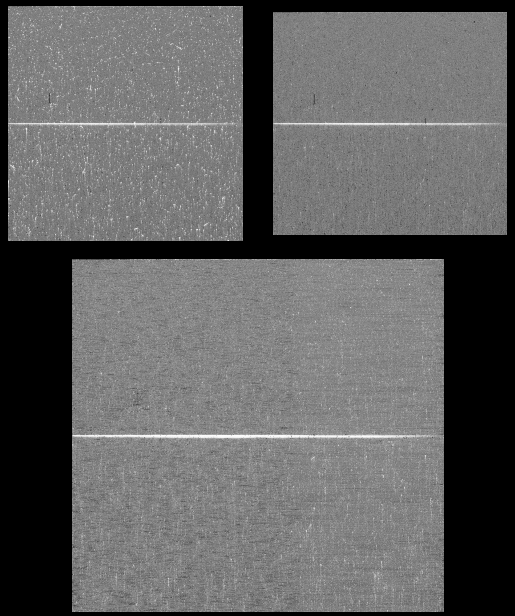
Optical through near-infrared spectrum of W2M1220+1126 (black line). A reddened quasar template with $E_{B-V} = 0.24$ is overplotted with a red line, and an unreddened quasar template is shown in blue



Reducing the STIS Spectrum:

1) Standard STIStools Reduction:

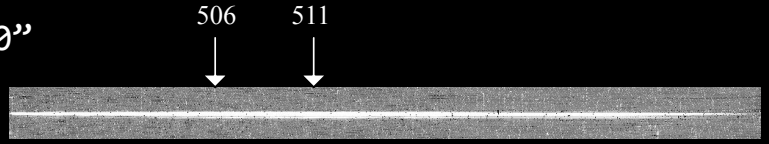
`OCRreject`
`MkFringe`
`Defringe.defringe`

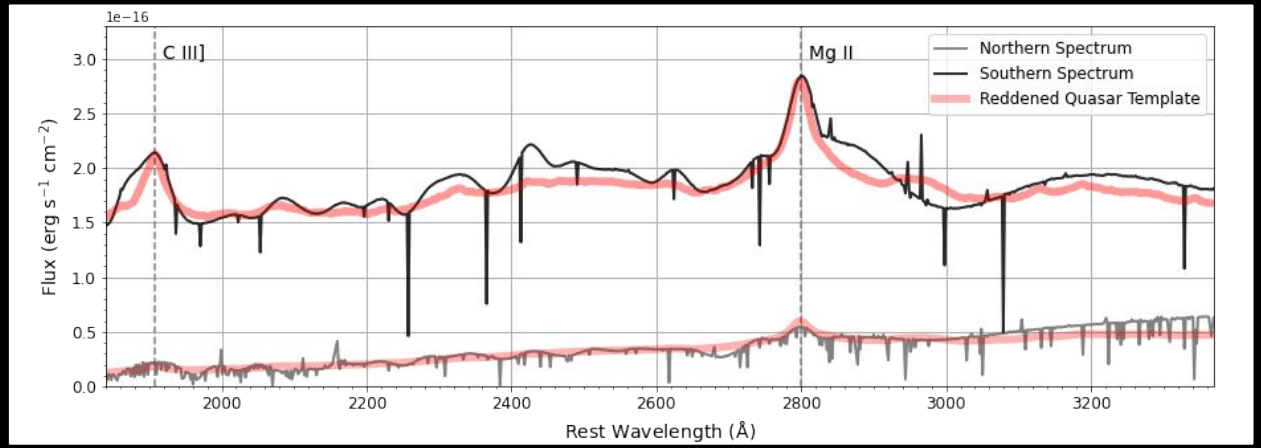


2) Deblending `x1d` routine with parameters:

`MAXSEARCH = 1.5”`
`A2CENTER = 506” & 511”`
`Extraction Box Size = 3”`
`Subtract BKGRND = 10”`

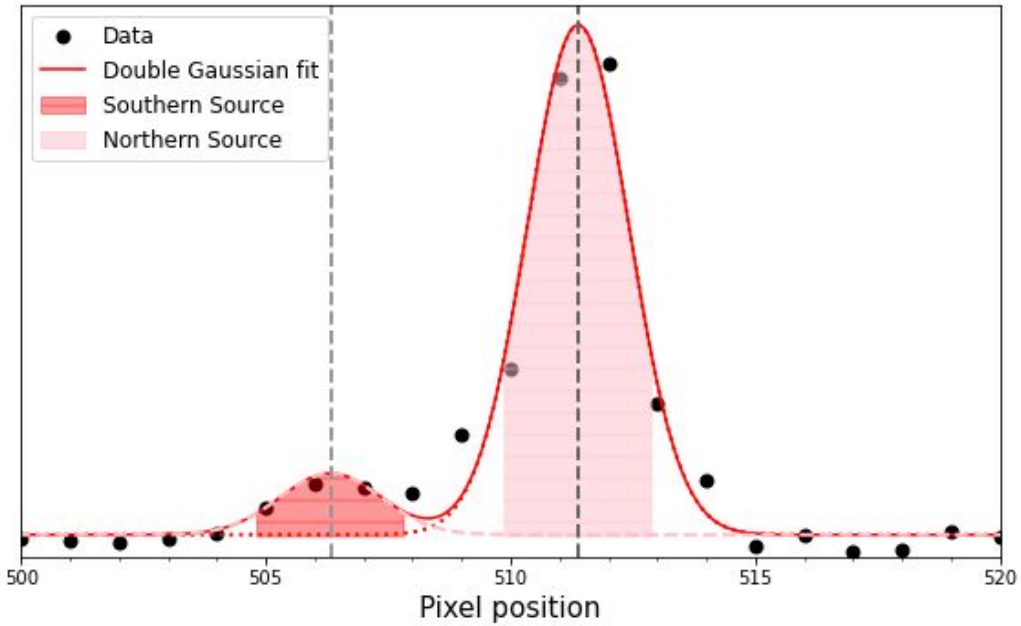
3) Plot the extracted spectra!





De-Blending Evaluation:

- ★ Sum of the cosmic-ray cleaned, normalized, and defringed science spectrum along the wavelength axis (i.e., the x-axis) and plot the spatial profile of the two object spectra
- ★ The pink and red shaded areas represent our 3” extraction regions, chosen to minimize blending
- ★ Two distinct peaks are shown with the southern spectrum overlapping the northern spectrum by ~ 0.6%



QSO Properties and Implications (STIS HST):

Source:	***E (B - V)*** **(mag)**	v_{FWHM} **(km s^{-1})**	**log M_{BH} (10^7 $M_\odot$)**	**log L_{bol} (erg s^{-1})**	***L/L_{edd}***
North	0.432	3140 ± 800	7.2 - 7.7	44.68	0.08 - 0.22
South	0.184	3800 ± 230	7.39 - 7.69	44.48	0.05 - 0.1

★ Given only ~30 red quasars have been observed with HST → *discovering a dual AGN in such a small sample* **suggests an elevated incidence of dual activity in red quasars.**

★ Since W2M J1220 was found serendipitously at cosmic noon, *a targeted high resolution imaging effort of red quasars at $z = 2 - 3$* **may be the most fruitful place to find dual quasars during a crucial phase of SMBH/Galaxy coevolution where both black holes are active at the same time.**

★ Identifying large samples of dual AGN will not only *constrain models of galaxy mergers and evolution*, but also the next generation **gravitational wave experiment, LISA, will inform the kinds of sources whose GW signal will be detected from the coalescence of SMBHs.**

Acknowledgements and References:

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THANK YOU!