# Extragalactic Astronomy II

## Lecture 3

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Apr-June 2021

# Quasars

We will discuss Quasars first and in some detail, since they exhibit many of the features of AGN.
Other AGN classes can then be described, by contrasting their properties with quasars.

# Question

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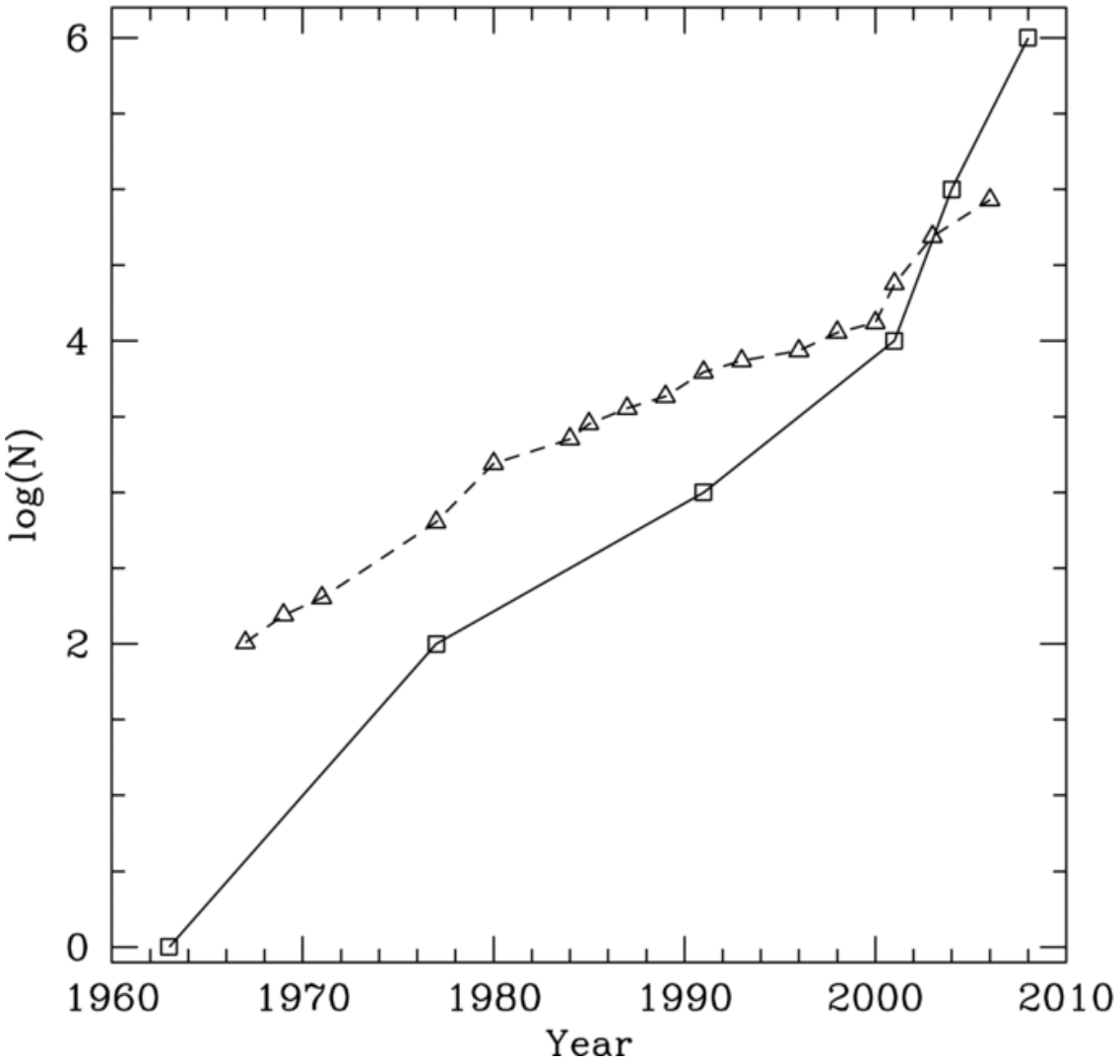
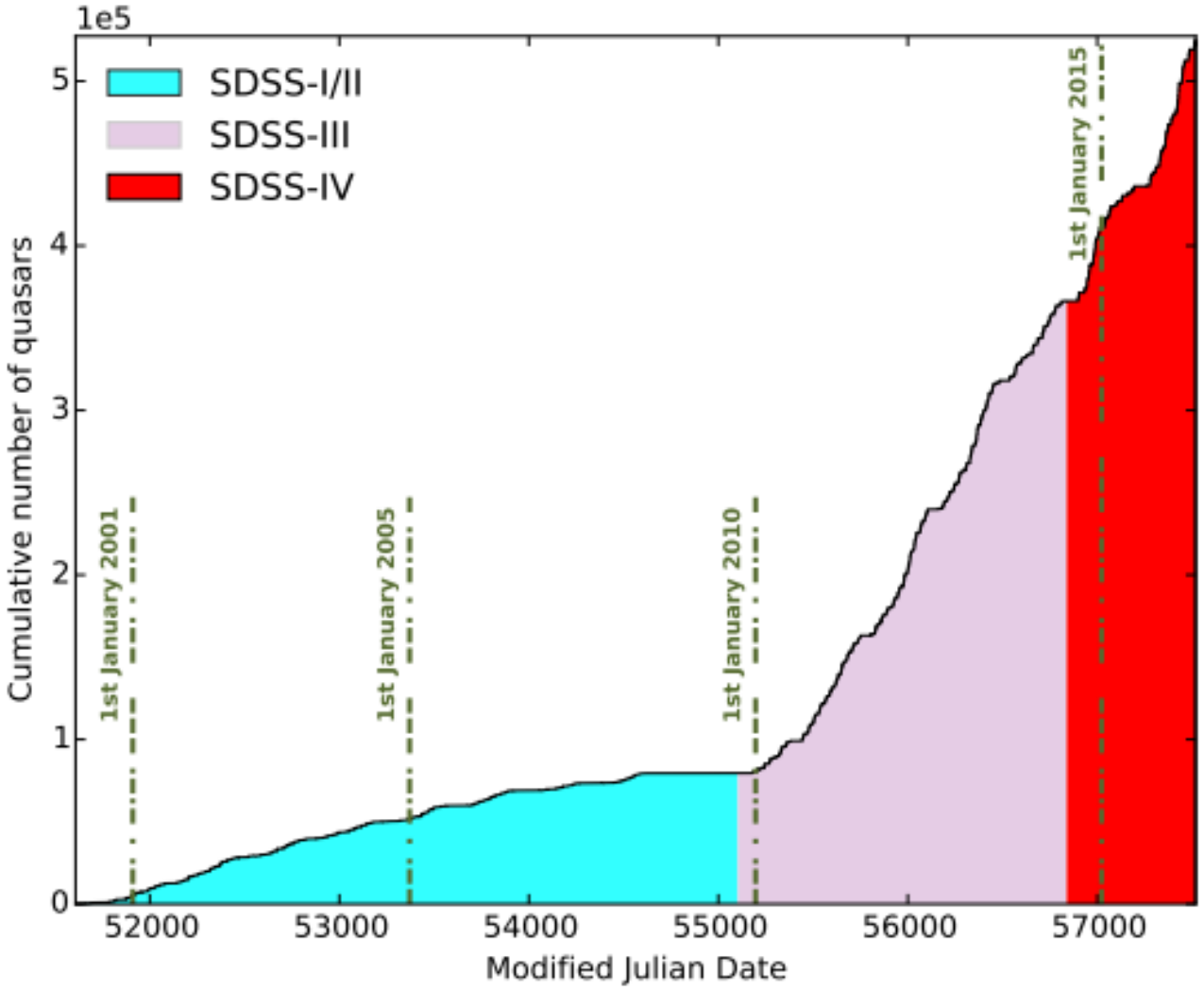
The Ooty Radio Telescope effectively used this technique to identify a large number of quasars and other radio sources in the 1970s

# Known quasars as a function of time




largest homogeneous (solid) and heterogeneous (dashed) quasar catalogs (last entries photometric). Richards et al. (2009)

# SDSS quasar discovery timeline

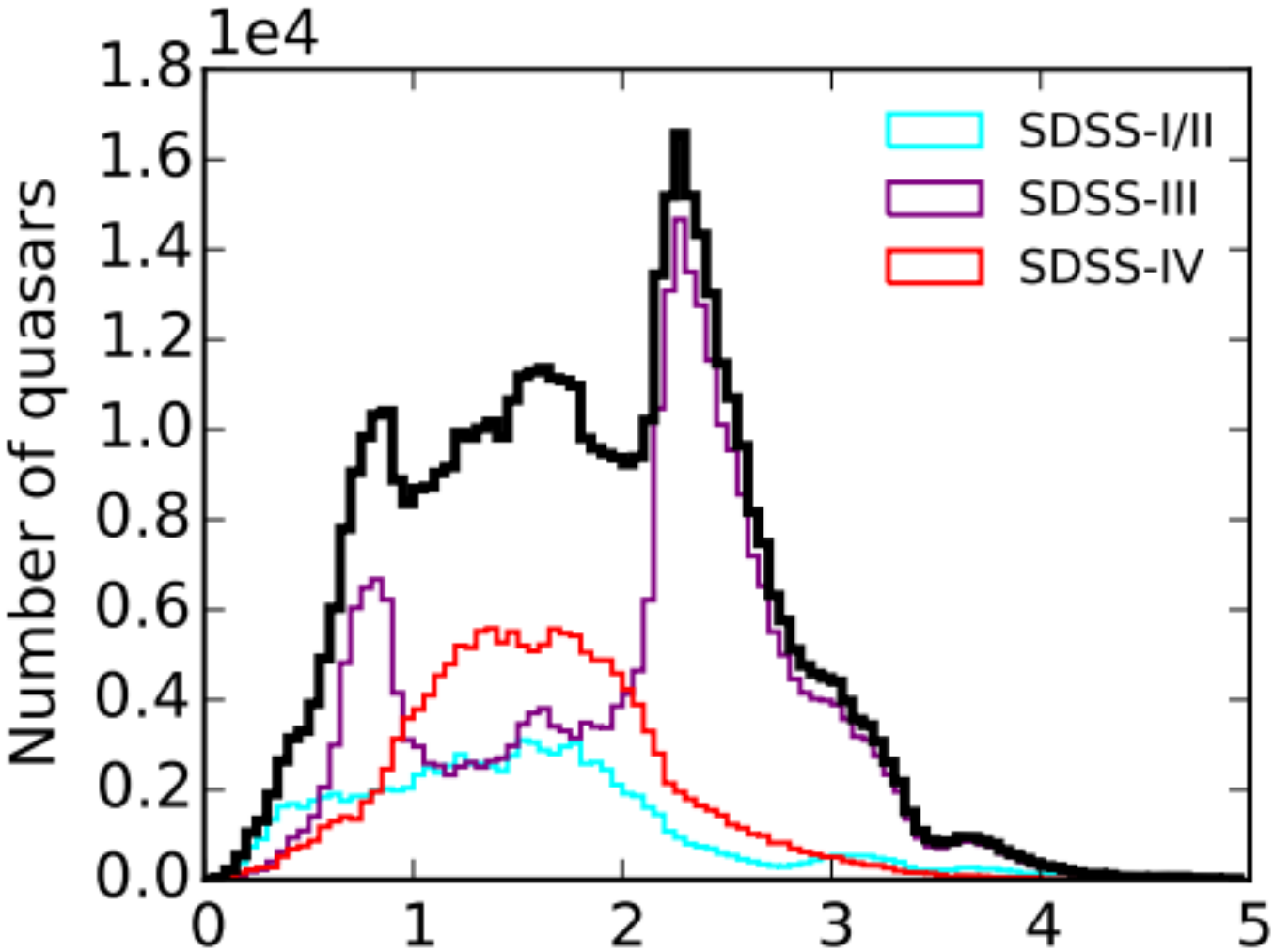



Paris et al. (2018)

# SDSS quasar catalog DR16

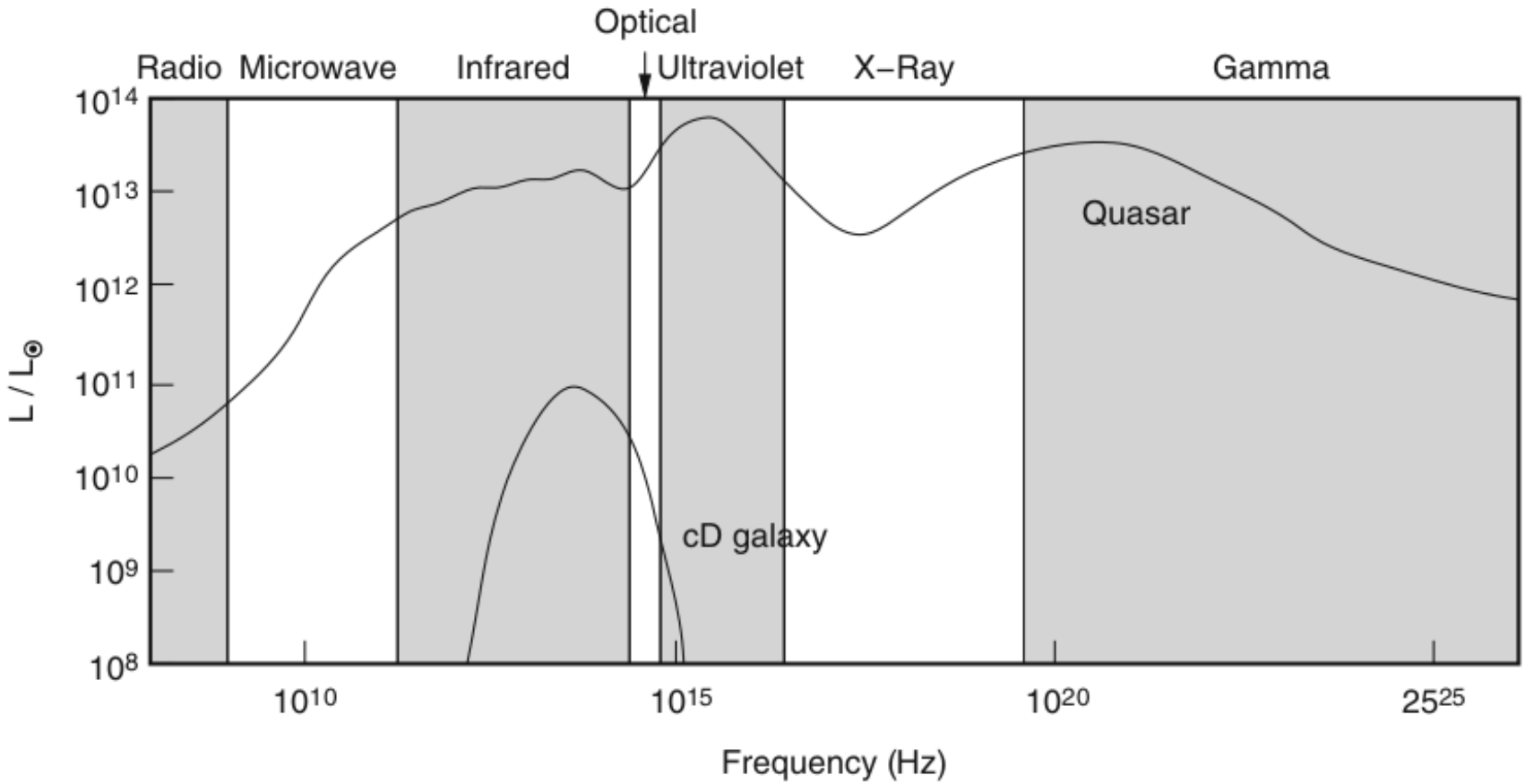
This catalog, which is the largest quasar catalog to date, contains data for 750,414 quasars, of which 225,082 are new in this data release.
$>$ 90% of these have very faint or undetectable radio emission.

# Redshift distribution of known quasars



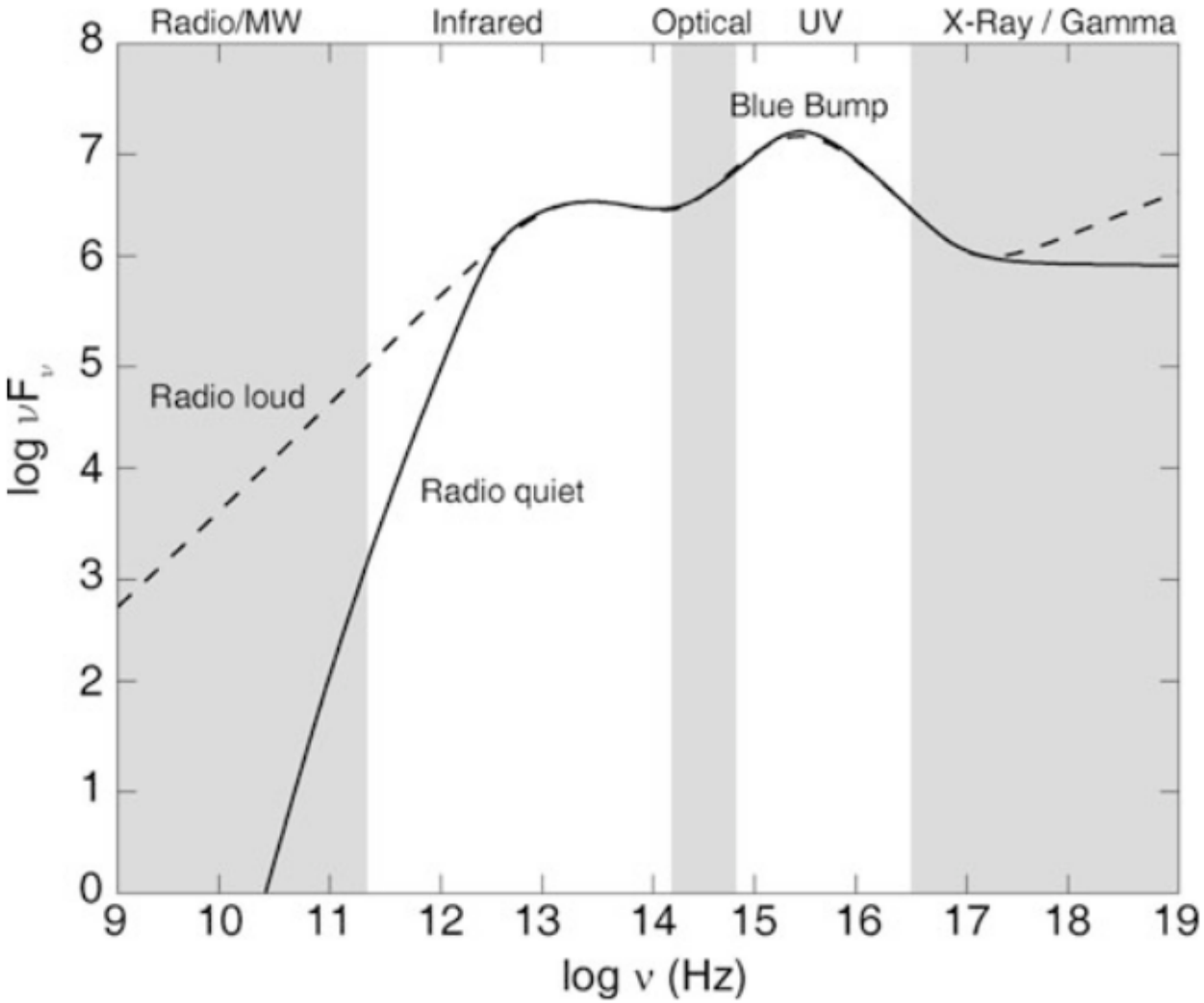

Paris et al. 2018

# SED of 3C 273 compared to elliptical

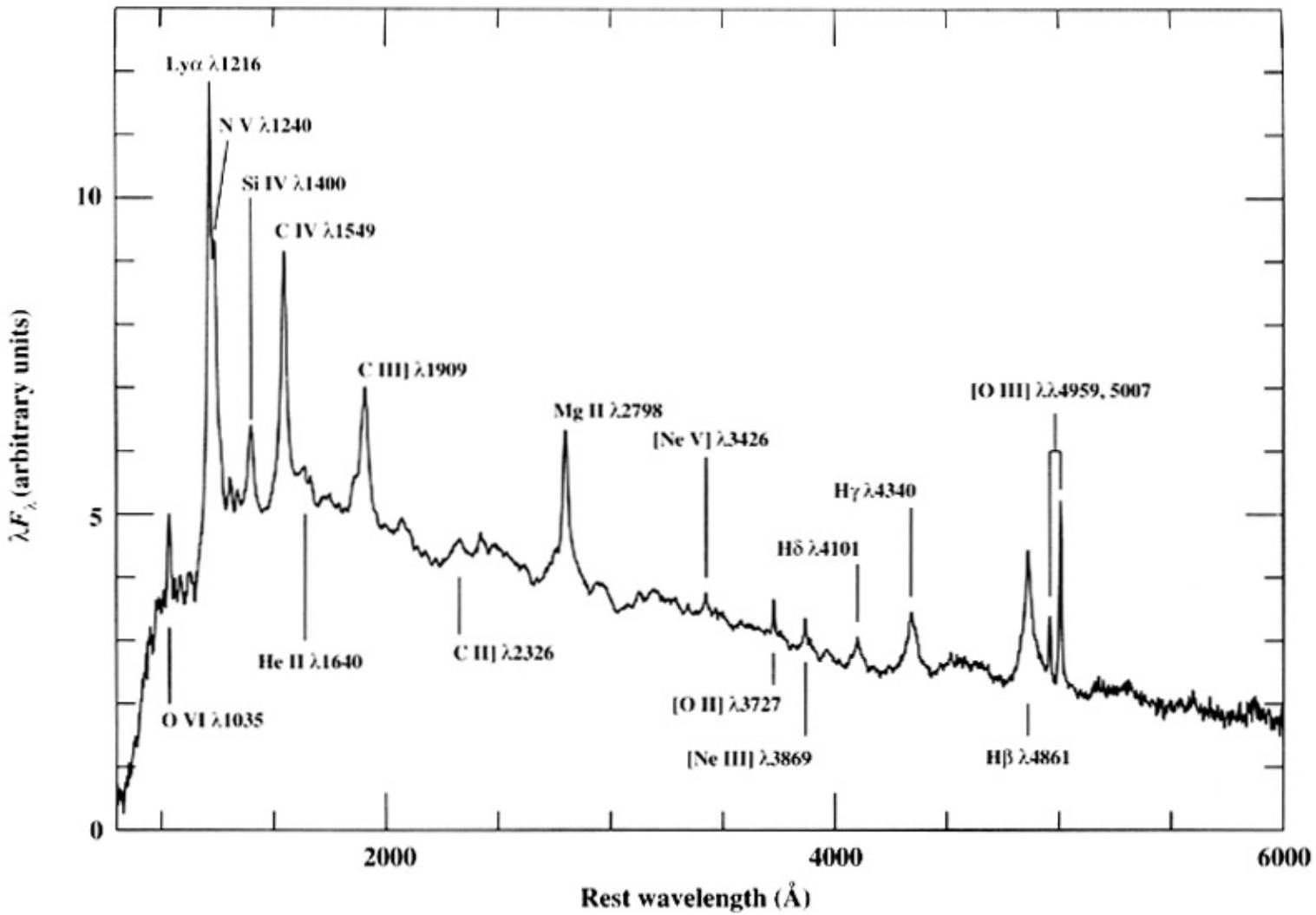



Luminosity is in $\nu L_\nu$ terms.

# Quasar SED features



# Composite quasar spectrum




Vanden Berk et al (2001)

# Forbidden lines

What are forbidden lines in a spectrum?

Forbidden lines represent atomic/molecular quantum transitions that have a low intrinsic probability and cannot be detected in lab experiments. They require special conditions to occur, in sufficient numbers to be detected.

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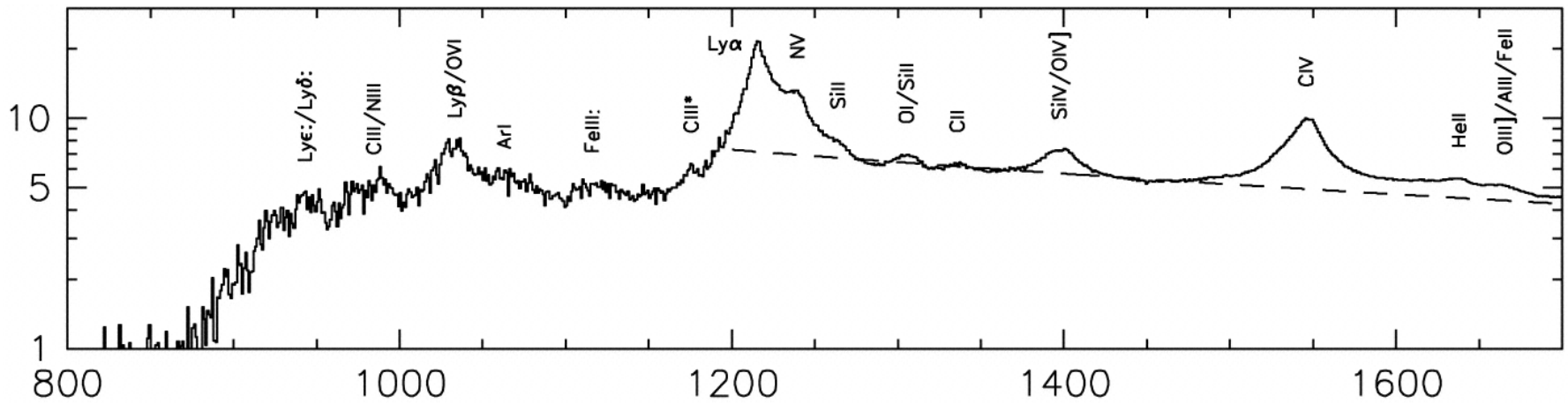
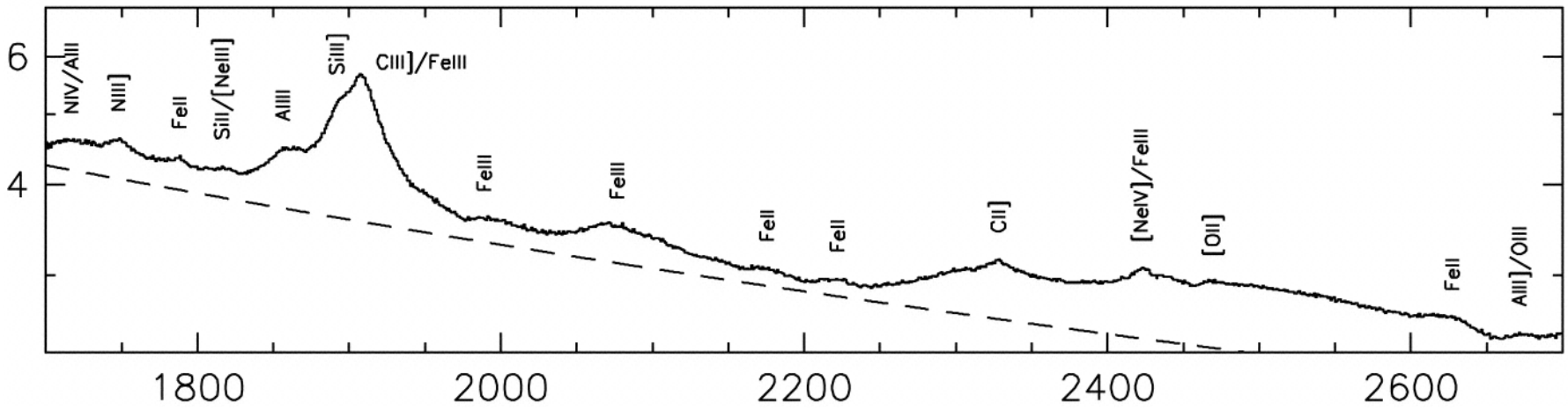
Similar forbidden lines exist without involving changes in principal quantum number. e.g. the hyperfine spin-flip transition of the hydrogen atom that produces the 21 cm line. Similar forbidden lines in rotational transisitions of molecules give rise to lines in the sub-mm and mm bands.

# Far UV quasar spectrum



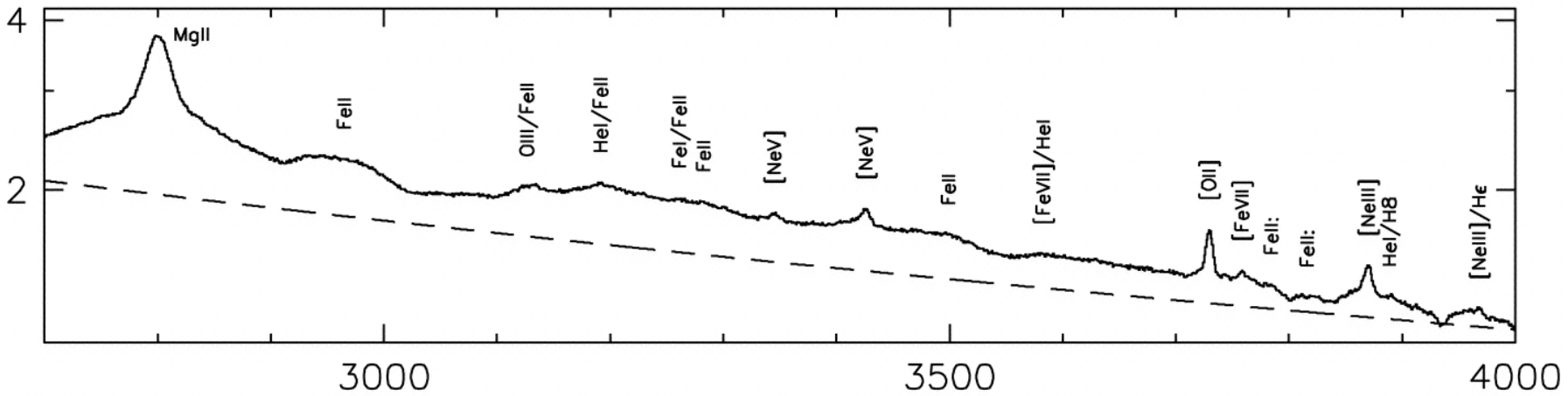

Vanden Berk et al (2001)

# Near UV quasar spectrum




Vanden Berk et al (2001)

# Optical quasar spectrum




Vanden Berk et al (2001)

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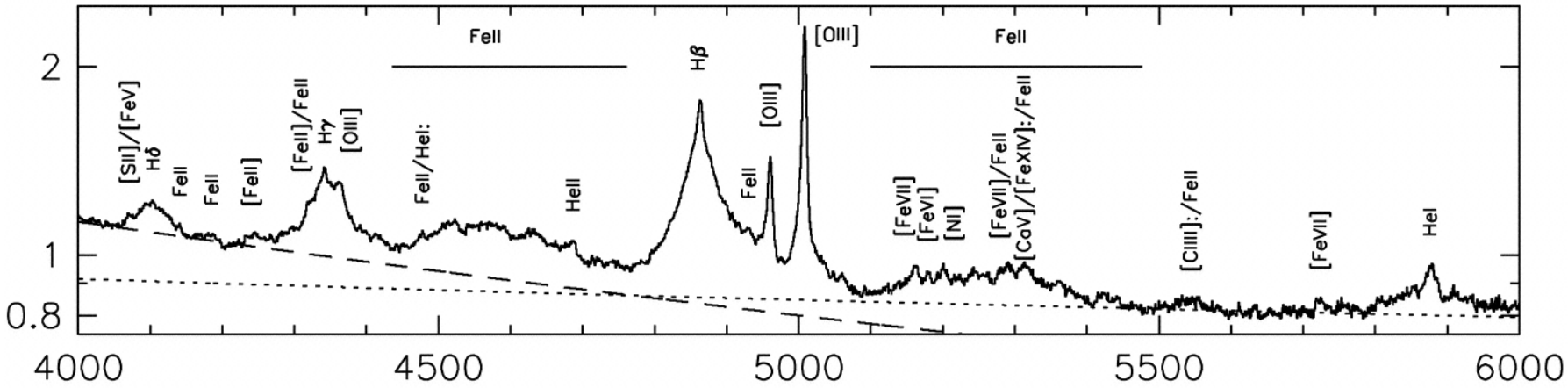


Vanden Berk et al (2001)

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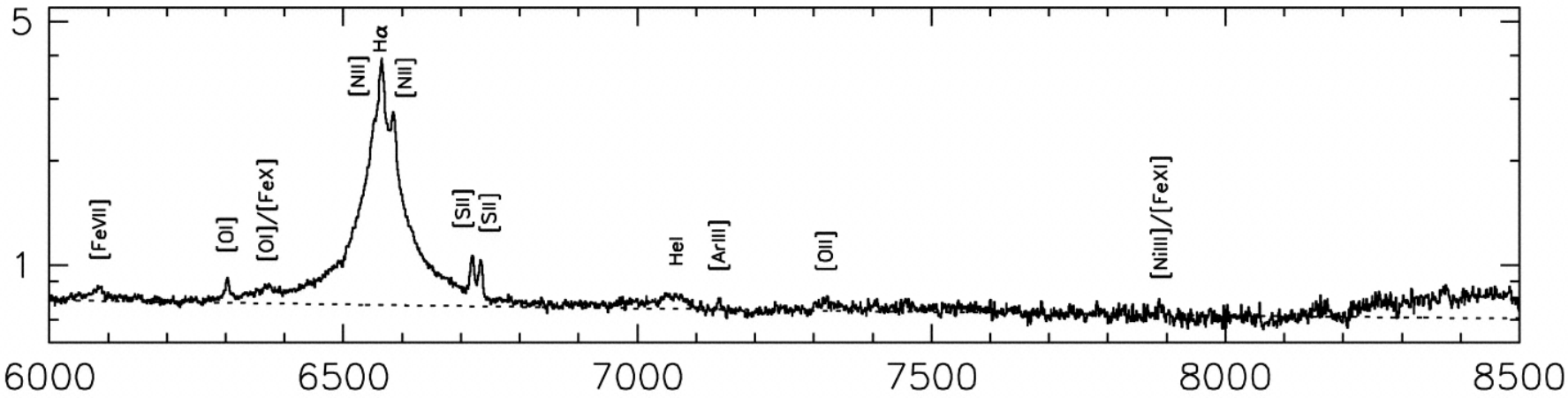
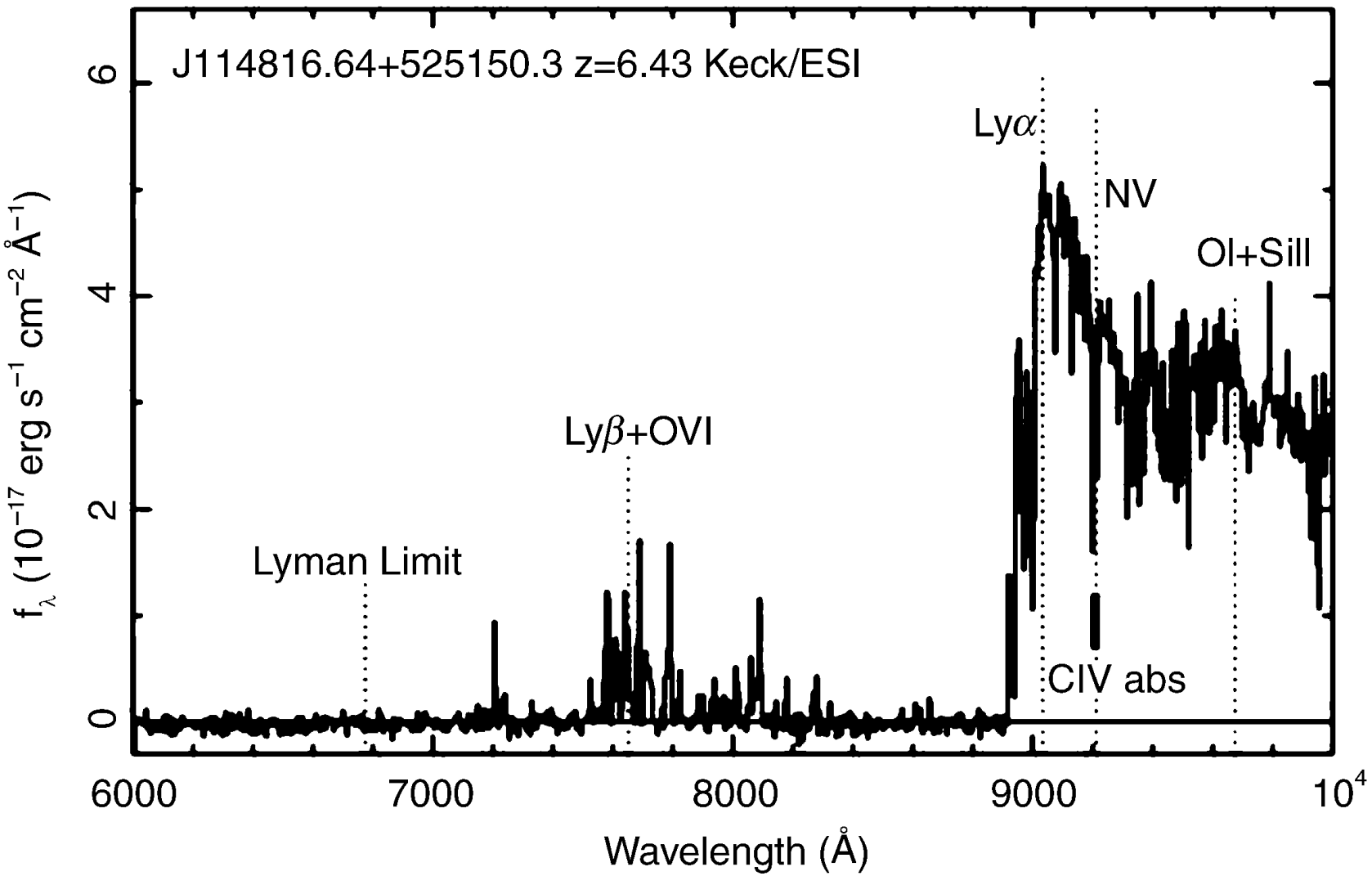



Vanden Berk et al (2001)

# High z quasar spectrum




What causes the Gunn-Peterson trough?

# Quasars as probes of intervening absorbers