

Seyfert galaxies with hyper-strong coronal emission lines (and other oddities discovered by SDSS)

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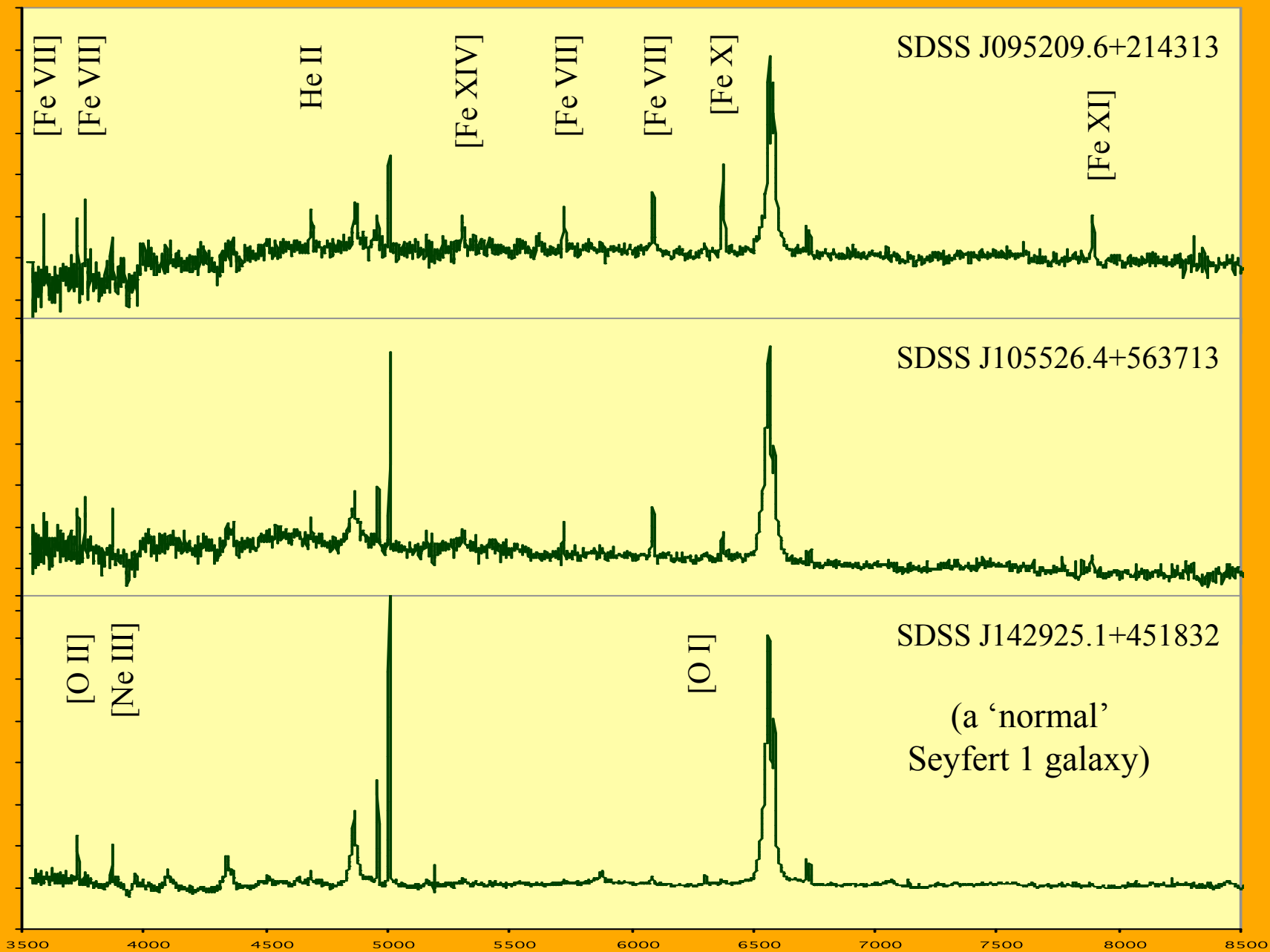


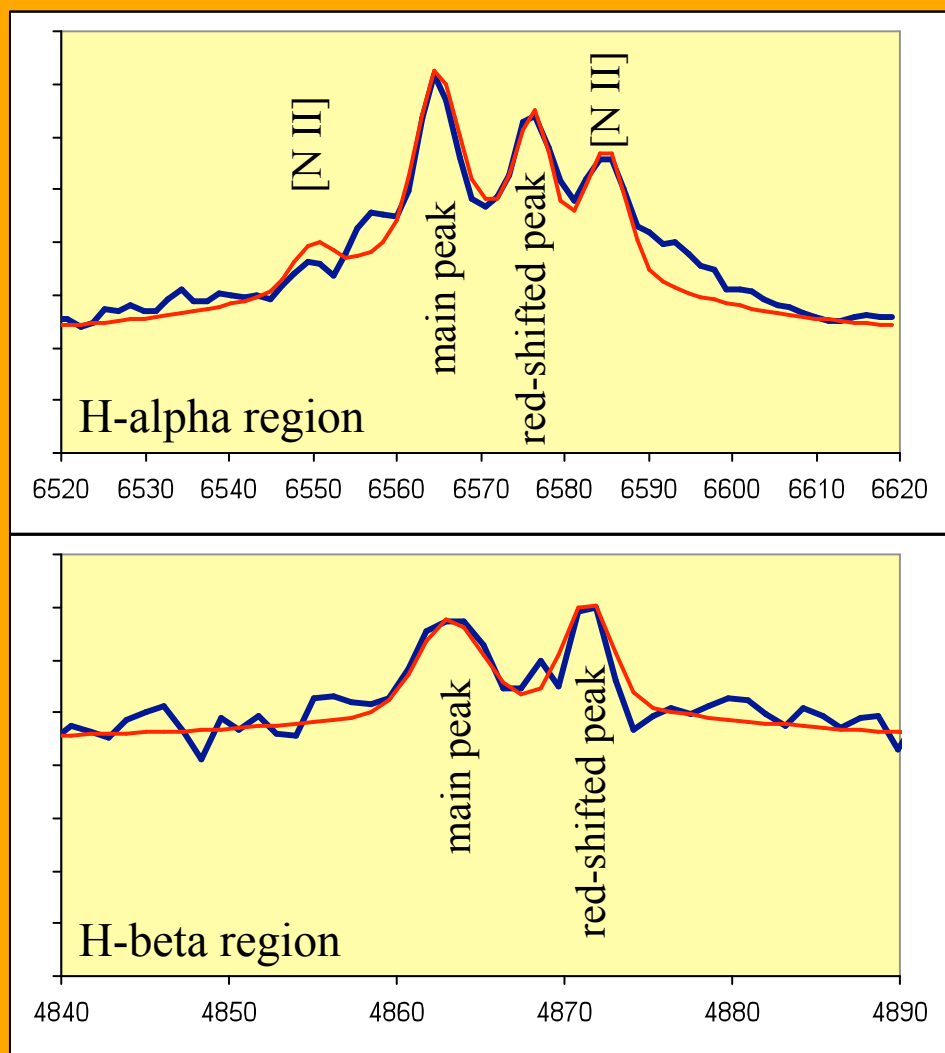
Description of investigation

- SDSS offers a unique opportunity to compare the spectra of 1000's of AGN, all recorded with an identical instrumental setup
- The spectra of all listed quasars, AGN and X-ray sources in SDSS with $z < 0.1$ were visually inspected to establish their AGN class
- The original Seyfert Type 1–Type 2 classification scheme is clearly oversimplistic (and even theoretically outdated)
- Over the years, various sub-classes have been identified, for example the narrow-line Seyfert 1's, or the presence of strong FeII–bands in some AGN
- The SDSS spectra instead highlight the rich diversity in AGN types
- No two spectra are exactly alike, but some commonalities are evident; there appear to be more sub-classes of AGN than hitherto accepted
- In this poster, two such apparent new classes of AGN are suggested
 - AGN with very strong coronal emission lines, and
 - AGN with strong broad He II emission
- In particular, this poster highlights one highly unusual AGN, with the comparatively strongest [FeVII], [FeX], [FeXI] and [FeXIV] lines known

Seyfert galaxies with exceptionally strong coronal lines

- Forbidden lines of multiply ionized iron lines are frequently detected in the spectra of Seyfert galaxies (e.g. Appenzeller & Östreicher, 1988)
- These are referred as the coronal lines, as they are also visible in the spectrum of the solar corona
- The fact that these are multiply ionized provides evidence of the very high temperatures of the regions in which these lines are formed
- It is likely that these regions lie much closer to the central black hole than the traditional narrow-line region, associated with [O III] and [N II]
- The higher temperatures and more intense ionising radiation in this AGN ‘coronal’ region leads to the presence of the multiply-ionized Fe II
- However, the density in these ‘coronal’ regions is clearly much smaller than in the broad-line region
- The line widths support this model; the ‘coronal’ lines are wider than the [O III] and other narrow lines, but much narrower than the broad lines
- Though so common in AGN spectra, coronal lines are not often mentioned in Seyfert galaxy studies
- SDSS however found some objects with remarkably strong ‘coronal’ lines (see spectra here below)





— measured spectrum
— fitted profile

Spectral peculiarities of SDSS J095209.6+214313

- Coronal lines
 - relatively strongest known
 - $[\text{Fe X}] 6374 > [\text{O III}] 5007$
 - wider than other narrow lines
 - all Fe ionizations prominent
- Second Balmer line peak
 - redshifted by ~ 500 km/s
 - narrower than main peak
- Asymmetric $[\text{O III}] 5007$ line
- More H-alpha components?

SDSS J095209.6+214313

Possible models for SDSS J095209.6+214313

A) Obscured broad line and narrow line regions?

- Obscuration of part of a nucleus is common, and has for example been determined as the reason why broad lines are not visible in Seyfert 2's
- We may here be looking at an AGN where much of the [O III] and [N II] line forming region is also hidden from view
- If the unobscured region is restricted to the 'coronal' region and small bits of the broad line region, these would dominate the spectrum
- This may also explain the peculiar second peak of the Balmer lines

B) A highly variable nucleus?

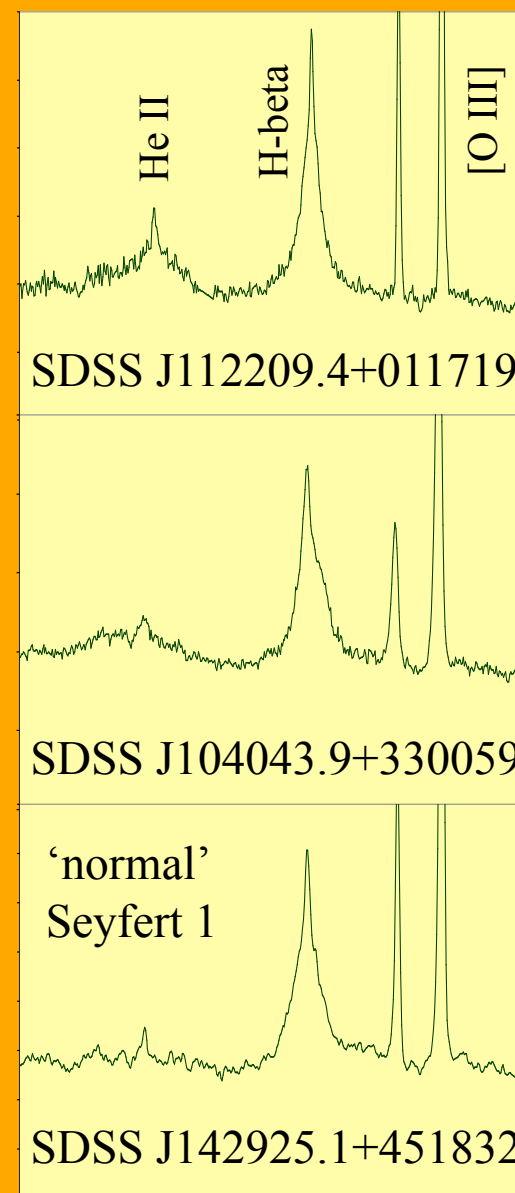
- Suppose the AGN is usually very quiet, but underwent a dramatic outburst
- The rise in luminosity is initially restricted to the broad line region
- A little while later, the luminous burst reaches the 'coronal' line region
- The [O III] region is further out, and thus at this stage unaffected by this outburst; at the same time, the broad line region returns to its low activity
- Thus the 'coronal' lines are temporarily much brighter compared to the rest of the spectrum – but a spectrum at a later epoch would be very different

Seyfert 1 galaxies with strong broad He II lines

He II commonly occurs in AGN, but usually just as a narrow line. There are however some objects (e.g. Mark 509) where a strong broad He II is also evident. SDSS has observed quite a few AGN displaying this characteristic. Some, like SDSS J104043.9+330059 (= RX J10407+3300) were previously known AGN (e.g. Veron-Cetty et al 2001), but there no mention had been made of the He II line.

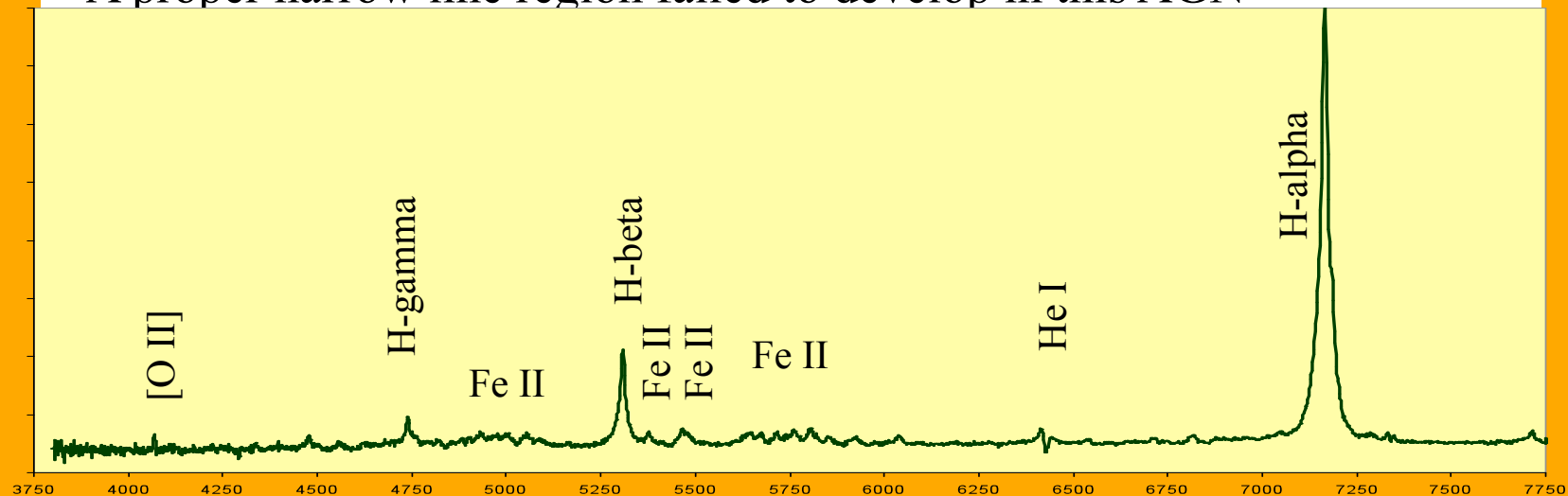
The He II line was measured by us in a number of such objects. It is generally broader than the broad Balmer line component. The line flux reaches above half of the H-beta flux in some cases.

We here seem to be viewing a hotter, faster-moving part of the broad line region than we are generally able to see. Presumably we are here viewing the innermost parts, which enables us to probe a part of the nucleus not traditionally explored with studies of the Balmer spectrum



An iron-rich NLS1 galaxy with a missing forbidden line region

- SDSS J120010.93–020451.8 was identified by Zhou et al (2006) as a narrow-line Seyfert 1 galaxy (NLS1)
- Its spectrum below displays something very unusual, especially for the less luminous, relatively nearby Seyferts – there are no [O III] lines
- The [O II] 3727 line is the only forbidden line visible
- The Fe II bands are quite prominent. The two features to the red of H-beta fit Fe II wavelengths much better than [O III]
- The [O III] line weakness is even more extreme than in the otherwise similar spectrum of I Zw 1 (see e.g. Boroson & Meyers, 1992)
- A proper narrow line region failed to develop in this AGN



Conclusions and follow-up work

- SDSS has led to a massive increase in the number of known AGN
- The homogeneity of the data set enables a far more sophisticated comparison of AGN – several new sub-classes of AGN become apparent
- The recognition and study of these sub-classes furthers our knowledge of AGN
- A further spectrum should be taken of SDSS J095209.6+214313, to determine whether the strong coronal lines persist
- Spectropolarimetry may unmask the hidden components in this AGN
- A more comprehensive, revised AGN classification scheme needs to be developed

References

- Appenzeller I., Östreicher R., 1988, AJ 95, 45
Boroson T.A., Meyers K.A., 1992, ApJ 397, 442
Veron-Cetty M.-P., Veron P., Goncalves A.C, 2001, A&A 372, 730
Zhou H., Wang T., Yuan W., Lu H., Dong X., Wang J., Lu Y., 2006, ApJS 166, 128