Studying "elusive" objects & Modelling the Near-Infrared FeII Emission in AGN

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A pathological case in the AGN family: "elusive" AGN

A typical case of schizophrenia: they are classified as one thing (e.g. Starburst) in the optical domain, and as an AGN in X-rays (scattered light).
Generally they are highly obscured in optical wavelengths (e.g. NGC 6221), and their structure is only shown in high spatial resolution observations (made through satellite or ground-based telescopes with AO/optimum seeing conditions)

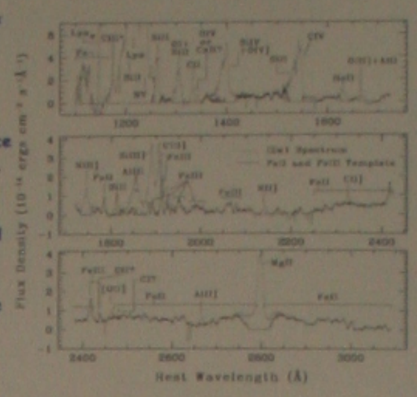
The Problem of FeII in AGN spectra

FeII comprises up to one third of the line emission in AGNs. Important coolant!!

Fe+ is a potential diagnostic of density, column density, turbulence temperature and continuum shape. Of cosmological interest.

FeII is complicated! Sophisticated models need to be developed.

Understanding FeII could be quite important for understanding AGN broad-line region emission!



- I Zw 1
- Mrk 493
- Ark 564
- PG 1448
- NGC 4051
- 1H 1934

Analysis of near-IR spectra of 7 objects

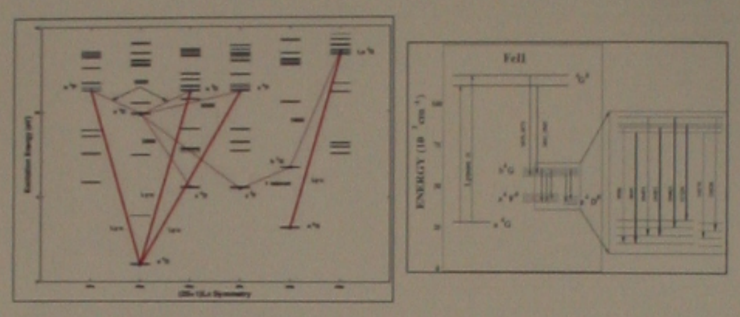
Most are NLSy1s: strong FeII emission + narrow "broad lines"

- ✓ Low BH mass
- ✓ High accretion rates

Ways to estimate this Mass?

Method: in continuum-subtracted spectra, a linear combination between each of the 12 synthetic FeII+Mg templates plus 17 emission lines (empirically modelled) for the permitted and forbidden lines were used in the fit.

FeII Energy Level Diagram

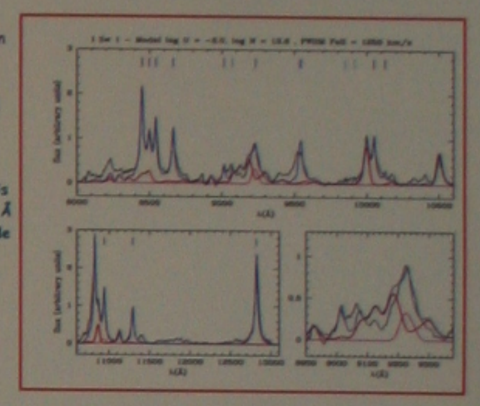


The picture to the left shows the FeII energy levels (285). Red thick lines marked the transitions pumped by Lyα fluorescence that lead to the NIR FeII spectrum. Lines marked with thin red are the primary and secondary decay lines following fluorescence. The right panel shows the Grotrian diagram of the 1μm FeII lines.

The case of I Zw 1

The plot shows the best fit found for the FeII spectrum in Izw1 (red line). The vertical thick marks indicate the positions of H, He, Ca, [SIII] and OI empirically modelled MgII lines are in magenta.

The plot at the bottom left is a zoom around the FeII 9200 Å lines. They are primary cascade lines following Lyα pumping, offering clear evidence of the presence of this mechanism in AGN.

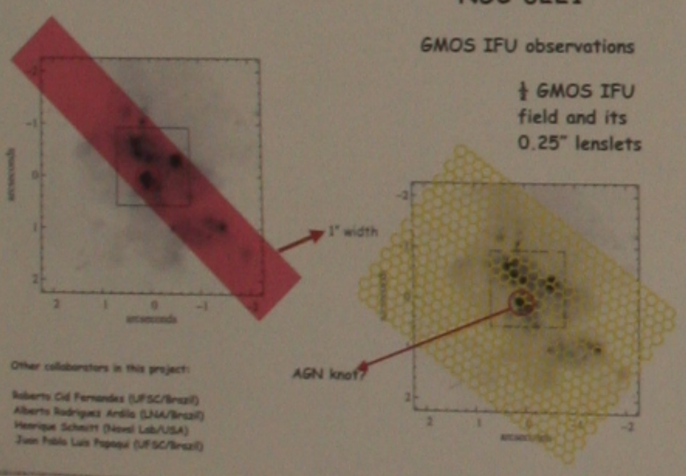


Traditional long-slit observations

NGC 6221

GMOS IFU observations

½ GMOS IFU field and its 0.25" lenslets



Other collaborators in this project:

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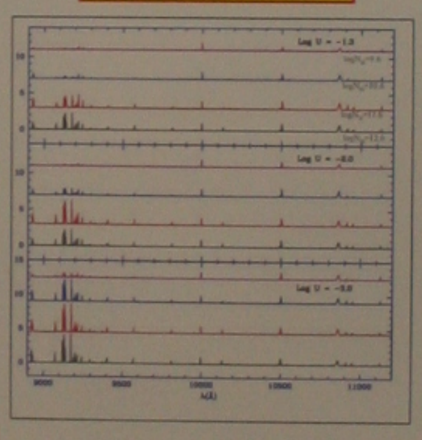
Alberto Rodriguez Ardila (LNA/Brazil)
Henrique Schmitt (Naval Lab/USA)
Juan Pablo Luis Pagaza (UFSC/Brazil)

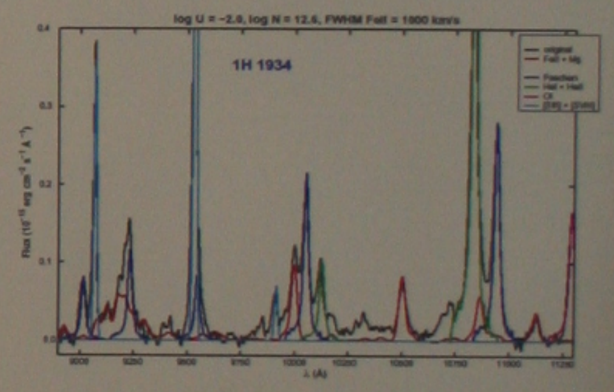
The FeII models

- The iron line fluxes were calculated following Sigut & Pradhan (2004).
- A background temperature and density structure for a single BLR cloud of a given ionization parameter (U) and total cloud density (N_H) was computed with Cloudy (Ferland 1991).
- The shape of the ionizing continuum was that of Mathews & Ferland (1987).
- Radiative transfer and statistical equilibrium equations were solved for a self-consistent set of iron level populations and line fluxes.
- Fluorescent excitation by Lyα and Lyβ were included.

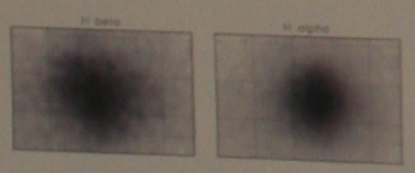


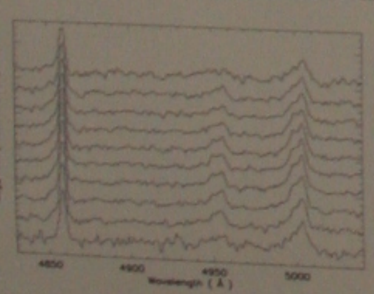
Best Fit models (based on χ^2 minimization)

The best solution found for the sample of objects points towards a large value of N_H ($10^{12.5}$ cm^{-3}) and moderate-to-high ionization parameter (log U >= -2).



Intensity maps and some kinematics of our observations

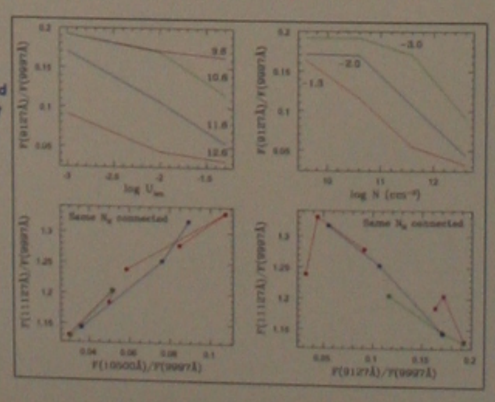




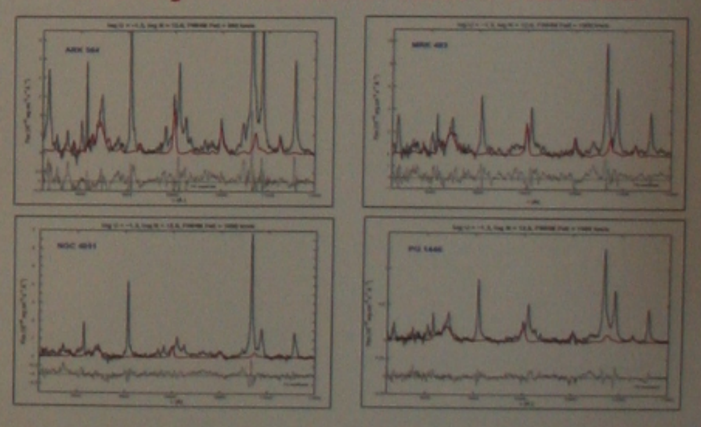
Emissivity vs Density and Ionization parameter

FeII 9127/9997 decreases with N_H. This in interpreted in terms of an enhancement of FeII 9997 because of collisions among high-energy pseudometastable levels of FeII excited by Lyα.

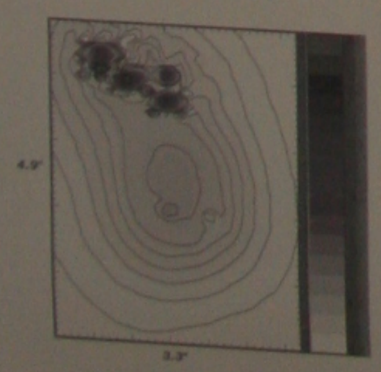
Line ratios among FeII lines set useful constraints on the physical conditions of the BLR gas.



Other examples of Seyfert 1 galaxies and a QSO with strong NIR FeII emission. Models vs Observations



Fitting Hα, one is able to get more details in the intensity maps (this is ongoing work on NGC 6221)



Goals of the work on "schizophrenic" AGN:

- ✓ To build velocity maps of the nuclear gas
- ✓ To build diagnostic diagrams for each array element, and identify the sources of gas excitation in both nuclei, separating the AGN and the starburst components
- ✓ To apply stellar population spectral synthesis techniques (using the newest Bruzual & Charlot templates library with 1 angstron spectral resolution)
- ✓ To extend this investigation to other wavelength domains, in particular, through high spatial resolution IR IFU observations (e.g. NIFS), with the aid of adaptive optics

.. helping to explain the so-called AGN-starburst connection.

Conclusions from the work on FeII modelling

- ✓ We have obtained additional observing evidence of the presence of Lyα pumped transitions in the FeII spectra of Seyfert 1 galaxies and for the first time, in a QSO.
- ✓ Theoretical models accounting this mechanism adequately describe the NIR FeII lines observed in a sample of AGNs.
- ✓ The FeII gas is characterized by densities >= $10^{12.5}$ cm^{-3} and log U=-1.3, -2.0. Collisional excitation is also found to contribute to the gas excitation.
- ✓ The large velocity component observed in the HI lines seems to be absent in the FeII lines, suggesting that the latter are indeed formed in a separated component of the BLR.
- ✓ NIR observations of FeII emitters can put firm constraints to the location and physical conditions of the FeII gas in AGNs.