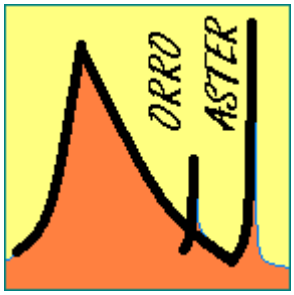

ZORROASTER

Z-limited Optical Region Register Of AGN Spectra, Types & Emission Ratios

Version 2: October 2013

Catalogue description and notes

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Overview

The past few decades have seen a massive increase in the number of identified active galactic nuclei (AGN), as evidenced by the dramatic growth over the years in the number of listed objects in AGN catalogues such as the one maintained by Véron-Cetty and Véron (Véron-Cetty & Véron, 2010).

Despite many (reasonably successful) attempts to reduce the AGN phenomenon to one common physical mechanism through grand unified models, even a casual scrutiny of assortment of optical spectra available reveals remarkable diversity. A number of schemes have historically been put forward to categorise wide range of spectra on offer. Seyfert's identification of the class of objects named after him, and its sub-types 1 with broad lines and 2 without (Seyfert, 1943), is largely still in use today, although there has been a recognition of various intermediate types (e.g. Osterbrock & Koski, 1976) that resulted in further Seyfert sub-classed coming into use: 1.0, 1.2, 1.5, 1.8 and 1.9. The last of these, defined as an AGN with a broad component visible at H-alpha but not H-beta, has always been interpreted as a highly reddened and thus obscured nucleus. Indeed, spectropolarimetry has revealed an obscured Seyfert 1 nucleus in many type 'normal' 2 Seyferts.

In the early 1980 came the recognition of a new class of AGN, a lower brightness nucleus with comparatively stronger low ionisation emission lines that became known as LINERs (reviewed by Filippenko, 2003). A lot of galaxies were also being discovered with strong emission line spectra resembling typical of galactic H2-regions. In view of the violent star formation these became known as starburst galaxies.

Next a class of Seyferts known as "narrow line Seyfert 1 galaxies", with broad line components barely exceeding in width those of the narrow lines, became established (Osterbrock & Pogge, 1985), and these have been the subject of much interest since then. Other spectral variables recognised include the relative strengths of FeII lines (e.g. Kovačević at al, 2010) and 'coronal' lines – very high ionisation forbidden lines such as [FeX] (e.g. Gelbord et al, 2009), or the presence of double peaked emission lines (e.g. Eracleous & Halpern, 1994).

A good recent review of AGN and associated fields of study may be found in Véron-Cetty & Véron (2006).

Why a new catalogue?

We have nowadays well-established AGN catalogues (such as the Véron catalogue) that are readily accessible online, as well as detailed galaxy databases (such as NED – the NASA/IPAC Extragalactic Database) that include extensive information on nuclear activity. While these resources routinely list the AGN activity class, they do so in very general terms.

In reality, no two AGN are alike. There are subtle differences in the spectral parameters even for objects within an established AGN sub-class that illustrate a diversity of physical conditions present in these sources. ZORROASTER allows researchers to easily compare AGN spectra by viewing common format spectral images. Where particular AGN are being studied it permits quick and easy access to images where spectral characteristics can be inspected. It further enables the easy generation of spectrally well-defined sub-samples for intercomparative investigations.

Finally, ZORROASTER has been limited to the volume of space with $z \leq 0.100$, for which some degree of completeness may be achievable in the foreseeable future. This also prevents the inflation of the catalogue size to unmanageable proportions in future. This makes it an ideal resource for AGN luminosity function and evolution studies.

Catalogue layout

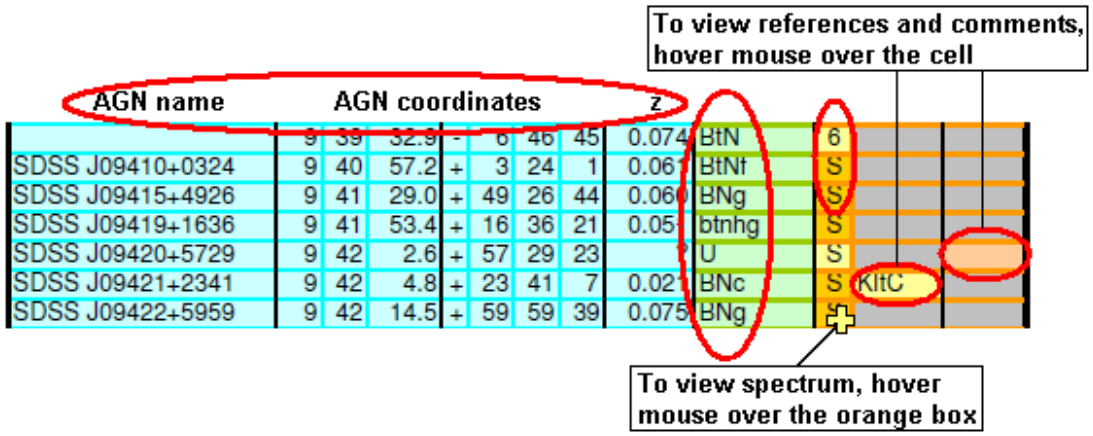
The first nine columns of the catalogue contain the name, coordinates and redshift of each AGN. Where available, these were reproduced from the latest edition of the Véron catalogue of quasars and active galactic nuclei (Véron-Cetty & Véron, 2010).

The (green) 10th column (column J) contains the spectral type descriptor, a set of encoded symbols that represent the features of the AGN optical spectrum. The spectral type descriptor codes are explained in detail later in this document.

Column K lists the source of the spectral image used to classify the spectrum. The symbols in this column represent the following:

S – Sloan Digital Sky Survey
V – Véron Catalogue of Quasars and Active Galactic Nuclei
Z – Smithsonian Astrophysical Observatory Telescope Data Centre Archive
2 – 2dF Galaxy Redshift Survey
Q – 2dF Quasar Redshift Survey
6 – 6dF Galaxy Survey
(arrow) – see the reference in column L

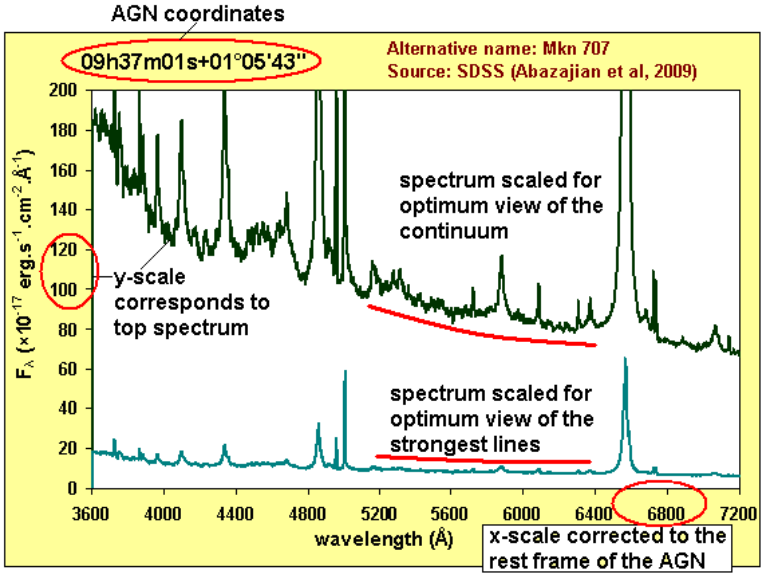
Column L lists a code for the reference to the best optical spectral image published in the literature, while column M contains occasional supplementary comments.



Additional information is embedded in the final three columns (K-M), that can be viewed by hovering the mouse over the cell. In the case of the orange cells in column K there is a spectral image of the AGN. Hovering the mouse over marked cells in columns L and M displays the full reference and a comment.

Layout of the spectral images

To view any spectrum, move the cursor onto the relevant cell in the ZORROASTER Excel spreadsheet and hover it there (no need to click anything). The spectral image will appear next to the cell, and basically looks as in the diagram below (note: only ORANGE cells have embedded spectra).



The spectral images are in PNG format, and always have the following layout:
i) The spectrum is reproduced twice, firstly (in black) with a y-scale optimised to view the continuum and weaker lines just above the continuum. The y-scale on the left corresponds to this spectrum.
ii) For the second reproduction of the spectrum (in blue-green), the y-scale has been optimised to highlight the relative strengths and profiles of the strongest emission lines.
iii) The x-scale has been converted to zero redshift (using the [OIII] 5007 Å line as the frame of reference) such that the same rest wavelength range (3600-7200 Å) is displayed for each AGN. So the same part of the spectrum (from [OII] 3727 Å to HeI 7135 Å) is viewed in each case, and relative line strengths may easily be compared from object to object.
iv) Additional information, such as the J2000 coordinates, common name (if any) and source of the spectrum (for this second 2013 version of ZORROASTER it is always the Sloan Digital Sky Survey), is listed above the spectrum.

... /PTO The Spectral Type Descriptor

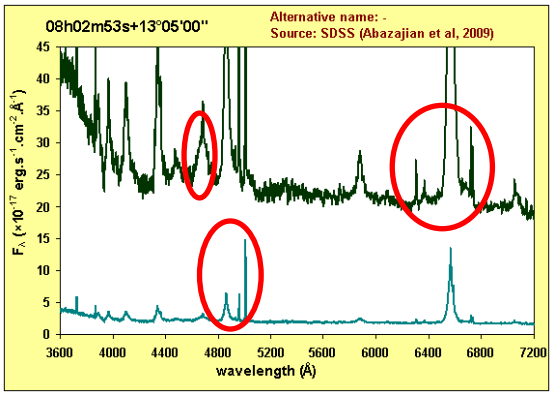
The Spectral Type Descriptors

b – presence of **b**road lines characteristic of AGN type Seyfert 1

In particular, a "b" indicates a broad line component unambiguously detected for H-beta. A "B" marks an H-beta intensity of the order of [OIII] 5007 Å or greater.

n – presence of a **n**arrow line spectrum with line ratios consistent with type Seyfert 2

Here too capital lettering implies greater line strength. In essence, the descriptor combinations Bn, BN, bN and N translate to Seyfert 1.2, 1.5, 1.8 and 2 respectively.



r – highly **r**eddened broad line region

Used to indicate that a broad component is only visible in H-alpha, but not in H-beta (i.e. a Seyfert 1.9).

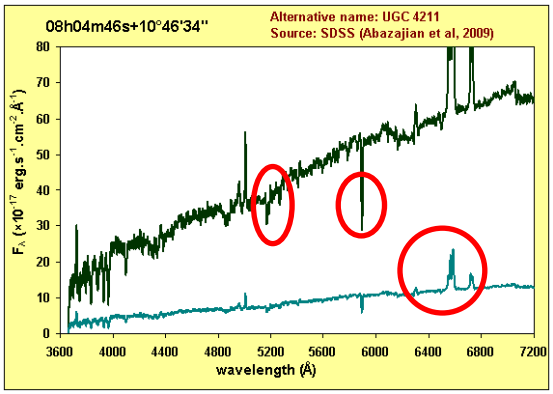
x – strong high e**x**citation broad lines

This descriptor signifies an AGN with broad He 4686 Å visible and at intensity ≥ 0.1 times that of H-beta.

g – starlight from AGN host **g**alaxy

In practice it isn't possible to measure an AGN spectrum that does not include at least a small amount of starlight from the AGN's host galaxy. The size of this component is also a function of the slit size used to obtain the spectrum. This descriptor is therefore spectrum-specific rather than AGN-specific. A "g" indicates the clear presence of typical 'galaxy' spectral features such as the MgI 5173 Å band and CaII H and K. A capital "G" specifies that the galaxy spectrum dominates the AGN component.

y – as with "g", it highlights significant galaxy background light, but here the galaxy light is dominated by **y**oung stars, characterised by strong Balmer absorption.

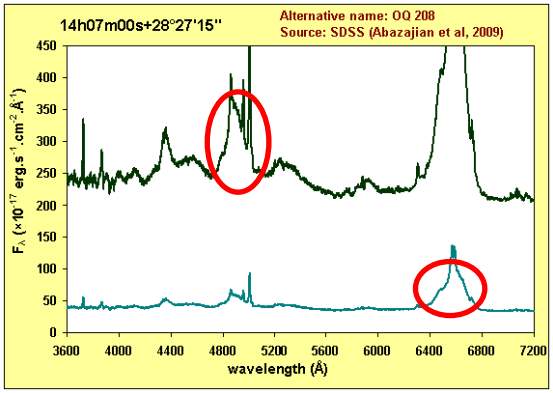


a – interstellar **a**bsorption spectrum

An AGN with a strongly reddened nucleus, shown by a steep continuum and a strong NaI 5892 Å absorption.

l – **L**INER spectral features

An emission component is present with line ratios typical of a LINER spectrum. A capital "L" indicates that the LINER spectrum dominates the remaining emission components.

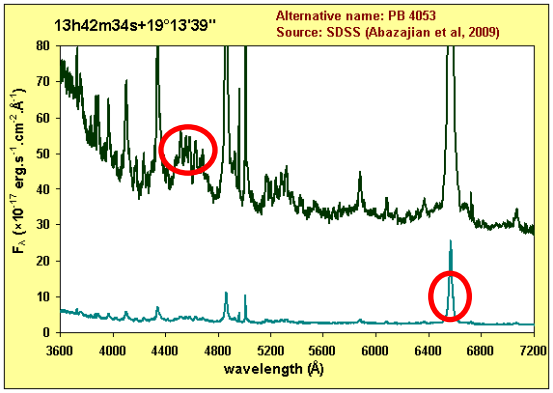


w – unusually **w**ide lines

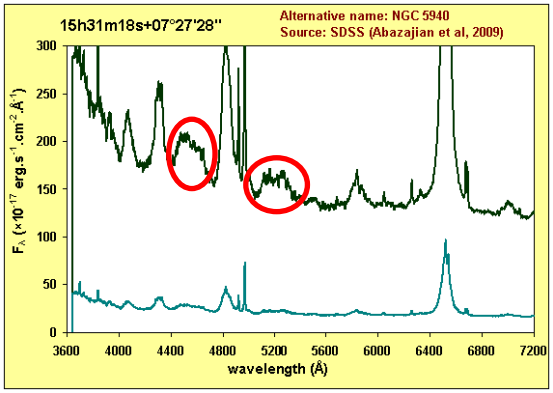
When "w" follows "b" then this refers to the broad lines, and an H-beta flux at base of [OIII] 4959 Å >10% of the H-beta peak flux. After an "n" it indicates broadened [OIII].

p – lines with unusual **p**rofiles

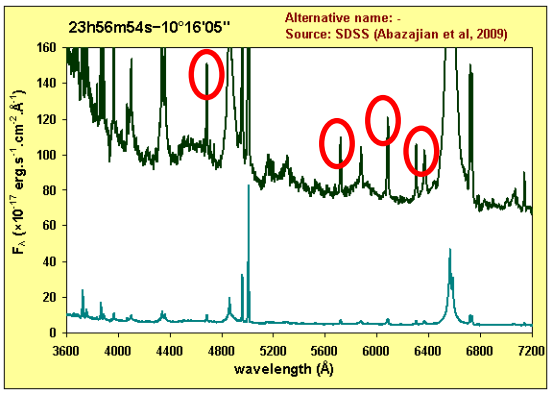
This descriptor signifies broad-line profiles that are strongly asymmetric or that have 'bumps'.



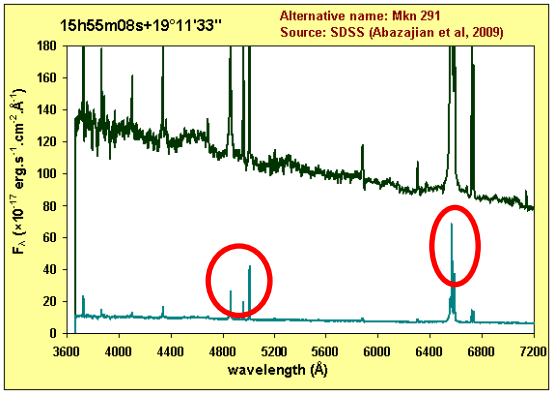
t – rather narrow (**t**hin) broad lines
This descriptor, immediately following a "b", typifies the class of AGN referred to as "narrow line Seyfert 1", where the broad lines have full-width-half-maximum of less than 2000 km/s. When combined with a rich FeII emission spectrum these are sometimes referred to as type I Zw 1 AGN, after their prototype.



f – **F**eII band spectra
AGN with prominent FeII emission lines, best visible in bands 4450-4700 Å and 5100-5350 Å. A capital "F", indicative of completely dominant FeII has only been associated with one AGN, the very unusual Mkn 231. AGN that in addition to FeII have line widths corresponding to the "t" class are referred to as I Zw 1 class objects.



c – **c**oronal line spectra
typical emission lines of this class are HeII 4686 Å (narrow), [FeVII] 5721 Å, [FeVII] 6087 Å and [FeX] 6374 Å, and these are here of the order of (or stronger than) [OI] 6300 Å. A capital "C" corresponds to the extremely rare case where the coronal lines are amongst the strongest narrow lines visible.



h – **H**2-region spectra
A starburst galaxy exhibits high star formation activity. Its emission line spectrum resembles that of a galactic H2-region. Typically, H-beta ≥ [OIII] 4959 Å, while [NII], [OI] and [SII] are weak compared to H-alpha. An "h" indicated a starburst component is present, while an "H" indicates that H2-region emission is dominant.

u – the spectral classification is **u**ncertain or completely unclear ("U")
v – a spectrum that has shown considerable **v**ariability over the years
***** – the spectrum of a foreground star is superposed over the AGN spectrum

The Markarian extension

A special supplement has been created for version 2 that includes the entire list of Markarian galaxies (including objects with z > 0.1). This supplement has the same basic format as features as the main ZORROASTER catalogue, but it is sorted by Markarian number, which is given in the first column (meaning that the other columns all shift by one). Where spectral classifications were not verified independently the class given by Petrosian et al (2007) is usually listed.

Databases

I. Sloan Digital Sky Survey – Data Release 7
Abazajian et al (2009); website: http://www.sdss.org/
II. Véron catalogue of quasars and active galactic nuclei, 13th edition
Véron-Cetty & Véron P (2010);
website: http://cdsarc.u-strasbg.fr/viz-bin/Cat?VII/258
III. Smithsonian Astrophysical Observatory Telescope Data Center Archives
website: http://tdc-www.cfa.harvard.edu/archive/
IV. 2dF Galaxy Redshift Survey - Final Data Release
Colless et al (2003); website: http://msowww.anu.edu.au/2dFGRS/
V. 2dF Quasar Redshift Survey (2QZ)
Croom et al (2004); website: http://www.2dfquasar.org/
VI. 6dF Galaxy Survey
DR3 paper: Jones et al (2009); original paper: Jones et al (2004);
website: http://www-wfau.roe.ac.uk/6dFGS/
VII. NASA/IPAC Extragalactic Database (NED)
website: http://nedwww.ipac.caltech.edu/

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II. Véron catalogue of quasars and active galactic nuclei
The Véron-Cetty & Véron catalogue has long been the prime reference for AGN identification. This work extensively used the 13th edition of this catalogue. The name (column A), coordinates (columns B-H) and redshift (column I) have in most cases been adopted unchanged from this catalogue.

III. Smithsonian Astrophysical Observatory Telescope Data Center Archives
ZORROASTER uses data products produced by the OIR Telescope Data Center, supported by the Smithsonian Astrophysical Observatory.

IV. 2dF Galaxy Redshift Survey
The 2dF Galaxy Redshift Survey was made possible through the work of the staff of the Anglo-Australian Observatory

V. 2dF Quasar Redshift Survey (2QZ)
The 2dF QSO Redshift Survey (2QZ) was compiled by the 2QZ survey team from observations made with the 2-degree Field on the Anglo-Australian Telescope.

VI. 6dF Galaxy Survey
ZORROASTER uses data that come from the Final Release of the 6dF Galaxy Survey.

VII. NASA/IPAC Extragalactic Database (NED)
This research has made use of the NASA/IPAC Extragalactic Database (NED) which is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.