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AGN research with TAUVEX

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Abstract. This review describes the major scientific issues related to the study of active galactic nuclei with TAUVEX. The physical motivation is briefly discussed and examples of projects suitable for the mission are given with specific ideas about the optimal use of TAUVEX for achieving these goals.

Keywords : galaxies: general – galaxies: nuclei – quasars: general – galaxies: starburst – galaxies: Seyfert – ultraviolet: galaxies

1. General scientific issues

TAUVEX has the capability to add, substantially, to the understanding of the ultraviolet (UV) and variability properties of active galactic nuclei (AGN). The general hope is to learn more in the following five areas related to AGN research:

- Black hole and galaxy evolution
- The earliest AGN
- AGN and black hole physics
- AGN unification
- Special types of AGN

The aim of this short review is to present these areas, without going into detail, and to suggest an observing strategy that can lead, after about three years in orbit, into a deeper understanding of the AGN phenomena and a better description of various AGN, from the nearby least luminous sources to the most luminous objects in the universe, at redshifts of about 2–3.

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2. General AGN observations

General experimental AGN research deals with a large variety of observable phenomena such as: 1. The properties of the nonthermal continuum of AGN through a detailed study of the spectral energy distribution (SED) and its time and frequency dependence. 2. Emission line properties via detailed spectroscopy, mostly in the IR, optical and UV parts of the spectrum. 3. Properties of the accretion disk via detailed SED studies over a limited wavelength range, the correlation of line and continuum properties and polarization observations. 4. Properties of the X-ray source, from absorption by lines and edges, that give clues to the amount of the line-of-sight material and its motion, to attempt to discover relativistic signatures such as extremely broad K_{alpha} lines. 5. Radio properties looking for synchrotron emissions, jets, orientation etc. 6. AGN obscuration, the attempts to classify such sources into two categories (type-I and type-II AGN) and the nature of this sub-division. 7. The starburst signature in AGN and the general connection between those properties.

The above partial but already long list suggests the need for a variety of techniques and instruments and a combination of ground-based and space-borne experiments. TAUVEX aims at providing new observations in a restricted area where, so far, there has been little progress. A key issue is the ability to observe a large number of AGN with known redshifts. This was not possible until about five years ago when the first large scale projects like the 2-degree field (2df) and the Sloan Digital Sky Survey (SDSS) started to produce such information to relatively faint magnitudes and for many sources over most of the redshift range. Such surveys are the ideal basis for follow up studies with instruments like TAUVEX. Fig. 1 shows the i-magnitudes of 11,000 $z < 0.75$ type-I AGN observed in the SDSS.

3. What can be measured with TAUVEX?

3.1 The UV continuum properties of AGN

This has been done so far in great detail by IUE, HST and FUSE but only for a limited number of sources (several hundreds at most). Most of these sources are of low luminosity and low redshift. TAUVEX has the capability to observe in 2–5 intermediate and narrow band UV filters a very large number of AGN. This will help to constrain the population properties. In particular to test the idea that the UV-Optical SED depends on the source luminosity. This can be achieved by obtaining redshift and spectral information on large AGN samples that are already covered by ground-based observations. As illustrated in Fig. 1, such extensive data bases already exists.

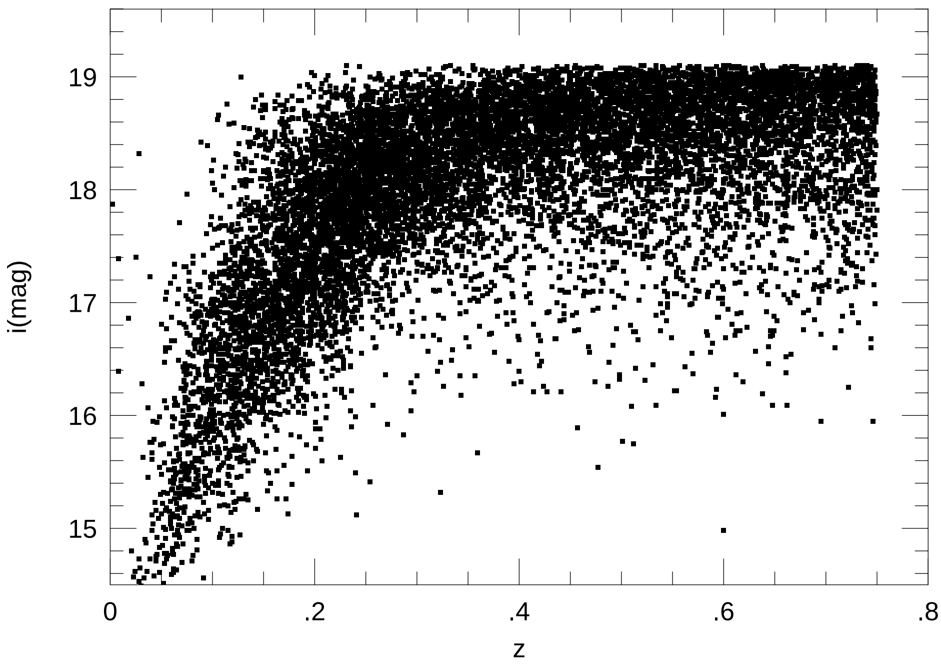

Figure 1. The i-magnitude distribution of 11,000 SDSS type-I AGN with $z < 0.75$.

3.2 Variability

This is a unique area where TAUVEX is likely to contribute the most. A clever scanning strategy can provide variability information on 1 day to three or more years time scales. Variability can be studied as a function of source luminosity redshift (available from new and existing optical surveys), emission line properties, etc.

3.3 Obscuration

The UV sensitivity of TAUVEX, combined with ground based spectroscopy, and X-ray information, can improve the understanding of AGN obscuration. This includes the size and the geometry of the putative obscuring torus, the dust properties, the fraction of type-I and type-II AGN as a function of redshift etc.

3.4 Population properties and new AGN samples

The local population of AGN vs. the population of high redshift AGN can be studied, more systematically with TAUVEX, in particular in samples defined by their UV properties. Here again we require a combination with large AGN samples like the SDSS and the 2dF survey. A very important aspect is the ability to use TAUVEX to discover AGN by their UV colour (or UV-Optical colours) and their variability. GALEX has only two UV colours and the use of the superior TAUVEX set of filters can open the door to the definition and subsequence studies of new AGN samples.

4. Possible observing programmes

Given the above areas of interest, and the orbital constrains, I suggest the following strategy for an efficient use of TAUVEX in the first three years of the mission.

4.1 Deep exposures of well observed AGN fields

There are several deep surveys in other wavelength bands that will be most useful to observe also with TAUVEX. Some examples are the Hubble deep fields (HDF) North and South, the Chandra deep field South (CDFS) and its equivalent in the North (CDFN) the X-ray XMM field HELLAS2XMM, Goods survey fields, GALEX fields and more. All of those are extremely small, much less than a square degree, and will require many TAUVEX repetitions in order to provide deep UV imaging. The main objectives are to obtain:

- UV colours at all possible redshifts (may be extremely challenging at very high z).
- UV variability and its correlation with (non-simultaneous) X-ray variability which is available for many of those sources.
- Use the UV-IR-X-ray combination of colour and spectra (several samples are already available) to test for obscuration and count the relative number of type-I and type-II sources. Such observations may be able to test the idea of the receding torus (smaller torus opening angle for higher source luminosity), the contribution of obscured AGN to the X-ray background radiation, the relationship between AGN and their host galaxy luminosity and mass, etc.
- Correlation of UV properties with mid-IR *Spitzer* properties (available for many of the sources in these fields). This has important implications to the AGN-starburst connection.

4.2 Shallower study of known large-area AGN fields

The SDSS and the 2df surveys cover a large fraction of the sky and are ideal fields for TAUVEX UV followup surveys. These are mostly equatorial fields containing a large number of sources with full spectroscopy follow-up (more than 40,000 type-I AGN of all redshifts and a similar or larger number of type-II AGN mostly with $0 < z < 0.4$. So far there is little or no UV and variability information on most sources which defines two obvious TAUVEX aims: a full UV survey (involving several dozens or more scanning per field) and a UV variability on various time scales, from 1 day to 3 years.

4.3 Study of AGN in TAUVEX fields

The TAUVEX consortium can choose to define its own areas of deep AGN surveys. Most suitable are high and low declination fields that enable very deep exposure for relatively little satellite time. For example, one can choose several (two?) large areas (> 1000 degree?) high declination fields and scan them to reach a magnitude limit deeper than the nominal GALEX depth in at least two UV bands. These fields will serve as our prime targets for looking for new AGN (which may require additional ground based photometry of the same fields or perhaps the use of the O and E plates of the Palomar Sky Survey) and UV variability. Such studies have never been attempted since the GALEX experiment has a different strategy and since it does not have such a large set of UV filters and bands. One can also think of a more challenging and difficult idea of simultaneous optical-UV monitoring of pre-selected small fields. The Wise Observatory 1m telescope, and several optical and radio Indian telescopes, can be instrumental in such combined projects.

4.4 Additional TAUVEX projects

Finally, we note that there are several less general AGN-related areas that can benefit from TAUVEX. Some examples are UV studies of radio survey fields, the study of specific targets like Blazars, BAL QSOs, and NLS1 galaxies, and more.

5. Summary of requirements and suggested strategy

The above highlights several but not all areas where TAUVEX can contribute to AGN research in a major way. Most of those, as well as other topics that have not been mentioned, involve deep UV imaging of large fields preferably to a uniform depth. An optimized strategy must be worked out to fit the expected variability of AGN. We suggested frequent visits to a few small fields (HDF, CDFS, CDFN), shallower surveys of several equatorial fields like the SDSS, and a deep survey of one or two new, medium size TAUVEX fields. TAUVEX time must be economically used to achieve these goals.

In particular, it is of utmost importance to follow the agreed upon strategy with as little interruption as possible and to give this mode of operation high priority over small individual projects. To satisfy the user community we suggest to open the AGN general projects to everyone who agrees to participate and to contribute to the work. The specific responsibilities will be assigned later on, once the observing program has been decided.

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