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TITLE: SPACE TELESCOPE CATALOGUE OF POTENTIAL STANDARIZATION TARGETS

AUTHOR: JAN KOORNNEEF

JK

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ABSTRACT

Informal discussions on the subject of ST-standarization targets have convinced me that the subject is sufficiently controversial to merit further attention.

The attached write-up takes the point of view that a major effort is needed to ensure a harmonious and mutually profitable relationship between ST- and ground based- data, both in terms of calibration input as with respect to science output.

I would be glad to receive comments and/or further information.

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SPACE TELESCOPE CATALOGUE OF POTENTIAL STANDARDIZATION TARGETS

It is rather widely perceived that the problem of photometric calibration of the Space Telescope is to assign a certain number of flux units per unit count rate to each of the modes ST can operate in. It is the purpose of this memo to argue that the real problem is to relate the output product of ST to established photometric and spectrophotometric "systems". As these systems typically bring an "absolute" calibration as part of their luggage, that aspect then takes care of itself. Hard to define generally what a system comprises, it is still possible to state some essential or desirable properties:

- there is a large, public, data base covering the full range of astrophysical parameters such as temperature, luminosity, brightness, reddening, chemical composition, etc.
- the data have been checked for internal consistency to a certain specified limit.
- these data cover both the Northern and the Southern Hemispheres as well as the equatorial zone.
- the data set is published and documented in the refereed journals. Instrumental descriptions including filter passbands, etc. are available.

- the properties of the system have been proven to be transformable, e.g. in photometry only small colour corrections are needed to transform measurements made with equipment other than the one original instrument.
- there is an absolute calibration.
- there is a large body of relevant scientific publications expressed in this system. Such data eventually work their way back into the system in the form of intrinsic colours, reddening and metallicity parameters, etc.

Very few actual systems satisfy all these requirements even for a wavelength range much smaller than covered by ST. But this is not for want of trying!

To elucidate the "system" concept in the ST environment, it is relevant to discuss the role of the International Ultraviolet Explorer in the standardization of ultraviolet astronomy. The output data of IUE can be regarded (in a kind of abstract way) as a set of flux-ratios with respect to η UMa. It is only after assigning an absolute flux distribution to this primary standard star that IUE yields fluxes. If better flux data for η UMa become available, all IUE results as expressed in flux-units, change. In the case of IUE, both the errors in the photometric accuracy of individual spectra and educated guesses about the validity of the absolute calibration are similar in magnitude

($\approx 10\%$) so that no changes in the absolute level have so far been considered necessary. Let us now assume that we want to adopt the IUE calibration for the relevant wavelength range (1200-3100 Å) to the various instruments and modes of ST. The problem of transferring the flux calibration would be trivial if the IUE-primary standard (η UMa) could be measured in all ST configurations. By adopting the same fluxes as for η UMa, ST and IUE would then have the same calibration. However, this star is much too bright for most ST-instruments, and a set of secondary standards is required.¹ Deriving such a set, primarily for "internal-IUE" purposes, has been an ongoing effort both at GSFC and Villafranca and a considerable data-base is now available. Many of the stars in these lists have also been measured by previous ultraviolet satellites and often were included for that reason in the first place. The present accuracy and internal consistency of the "IUE-preferred star list" is probably not quite sufficient for the application to ST and extensions on the faint side are definitely necessary. Work of this nature is already foreseen and new observations and checks of the internal consistency² are actually costed in Bohlin's "Calibration

¹ It is relevant to note at this point that such a list would be required anyway. Many functional tests require that the calibration objects cover a large range in brightness, temperature and/or reddening.

² For example, linearity will be checked by convoluting the IUE data with ANS-photometry passbands and comparing the results with the ANS-data. Cross-checks between different systems are important not only for validation purposes, but also provide the basis for the interrelation of science targets observed with the various ultraviolet satellites (such as OAO-II, TD1a and ANS).

Plan." When successfully completed, these efforts should ensure a solid basis for ultraviolet spectrophotometry and photometry in general, and ST in particular. Given the concentration of expertise on this subject within the ST ScI, it seems likely that the "IUE-photometric-system" can be successfully transferred to ST in all its modes for the wavelength region from 1200-3100 Å.³

So far so good. If ST were just a "far" ultraviolet satellite, the problem of defining a set of standard stars would be solved and everybody could concentrate on more pleasant things. The problem is that ST does happen to cover the "additional" wavelength range from 3100-10800 Å and calibration in this region also has to be considered. An alarmingly large number of "systems" are firmly entrenched in this region and the relevant photometric data-bases⁴ include the ANS-3300, the Borgman N-band, OAO 3320 and 4250 Å bands, the Stromgren u,v,b,y,H_β photoelectric system and the Johnson-Cousins UBVRI system in its many manifestations (CCD, photoelectric, photographic and electronographic). In the area of spectrophotometry, a multitude of photographic, image-tube, IDS, spectrum scanner and Reticon data-bases are presently available and in use at the major ground based facilities (for an excellent summary see Schmidt-Kahler; Landolt-Bornstein). These data-bases partly complement each other and in some ways are competitive.

³ This is with the provision that if the IUE-system and the optical system to be selected do not "connect smoothly", IUE flux levels might have to be adjusted.

⁴ The result of a superficial search for some actual references to calibration and standardization efforts is attached as Appendix A. Some personal comments have been added.

They are not necessarily on the same absolute calibration. Just as between 1200-3100 Å, the IUE-system is likely to be embraced, it seems unavoidable that one (or a combination of) "optical" spectrophotometric systems will have to be selected for ST use in addition to the Johnson & Stromgren photometric systems which are represented by their filter sets in WF/PC, HSP and FOC. Ideally, the primary standards for each of the adopted systems should be part of the ST-calibration data base. But in practice, these stars might not be suitable for ST, so that system-extensions have to be used. Such extensions might not be readily available and an observing program has to be initiated (such as planned for IUE). Unless dealt with in a very diligent way, the combined standard star list, satisfying the requirements for the support of all the "systems" to be embraced by ST, will be unacceptably long. Too much time would be wasted observing all these stars with ST and the result would still be a very fragmented data base where an instrument might have to change stars to calibrate its full wavelength coverage. In general, if the intersections between the various data-bases are too small, an unacceptably large amount of "bootstrapping" would have to be done. It is thus important that an attempt is made to create a real ST-standard star list rather than just a union of lists (near-infrared photometric, near-infrared spectrophotometric, visual photometry, ground based spectrophotometry, etc. etc.)

How about actually doing this?

- 1) Based on a very generous distribution list, find out:
 - what people consider relevant existing data-bases.
 - what activities are in progress which might be relevant.
- 2) Acquire all relevant data-bases.
- 3) Merge them and remove blatantly useless objects.
- 4) Create or identify software for:
 - sorting (by RA, luminosity, reddening, etc.)
 - plotting (equatorial, ecliptic, galactic, colour-colour, colour-brightness, etc)
 - file maintenance and history
- 5) Send highly documented lists of pre-selected objects to IDT's and ask them to identify targets suitable for their OV/SV and calibration requirements. Ask for "unsuitable/marginal/suitable/essential" on all stars in their lists.
- 6) Publish somewhat redundant lists of stars which are under consideration as ST-standards (in the ST-Newsletter?) and encourage all people to observe these objects.

TBD, TBD, TBD, etc.

Appendix A: Data bases

Optical Photometry

a) u, v, b, y, H_{β}

The catalogue by Hauck-Mermilliod (1980, A & A. S.S. 40, 1) and faint extensions by E.G. Schmidt (equatorial).

Establishing deep Stromgren sequences from CCD-frames can be handicapped by the tendency of some CCD-chips to produce fringes for the narrow passbands involved.

b) UVB (RI)_c

Work is done to extend the Johnson-Cousins systems to faint stars in E-regions, especially in South Africa and Chile (Landolt, Cousins, Menzies, Laing, Graham, Vogt, Geisse, Rojas). H. Ables is working on 6 "Naval Standard" areas with electronographic sequences similar to those of Purgathofer in Selected Areas 82 and 107. A photoelectric (B,V) sequence ($15.2 < V < 21^m$) in the field of the Draco dwarf galaxy has been published by Stetson.

Optical (and near-infrared) Spectrophotometry

- Oke's Palomar system (1964, Ap.J. 140, 689; 1969 PASP 81, 11); Stone's Lick system (1977, Ap.J. 218, 767) and recently (on the modified Oke system): Gunn and Stryker 1983, Ap. J. S.S. 52, 121 (also see Gunn and Oke, Ap.J. 266, 713), and many others.
- near infrared only: Dennefeld and Danks (Reticon, in preparation).

Optical spectrophotometry is biased towards the Northern hemisphere. Spectrophotometry can often profit from the availability of photometric data as the (non-chromatic?) light-loss at the input-slit can thus be corrected for.

In the ultraviolet:

 OAO-II photometry & spectrophotometry
 TD1a spectrophotometry
 ANS photometry
 IUE spectrophotometry

Polarization

Nothing is available in the UV below 3400 Å. In the optical, extensive lists are available (e.g. Coyne, Gehrels, Serkovski, Mathewson and Ford). Polarimeters currently tend to be in the Northern hemisphere.

Appendix B: Some random thoughts

- Why can a standard astrometric field not also serve for "deep" photometric calibration (or vice-versa)?
[h & χ Persei, Pleiades, Praesepe, globulars].

- Interstellar polarization tends to increase with reddening. A well selected sequence might well serve the need for standardization in both areas.

- The tendency to look for calibration stars in the continuous viewing zones, i.e. far from the ecliptic, runs contrary to the needs of ground based facilities. An overwhelming percentage of the proposed calibration targets is at high Northern latitude. Given the numerous other inputs in the calibration stars selecting process, being in the CVZ should be considered an asset rather than an absolute requirement. (How much of an asset is it really?)

- Coordinate with IAU Commissions.

- The high level specification on the photometric accuracy of all spectrophotometry is 1%. This means that the cross-calibration of all instruments should have that accuracy. But none of the available spectrophotometric data-bases is presumably that accurate for individual objects!