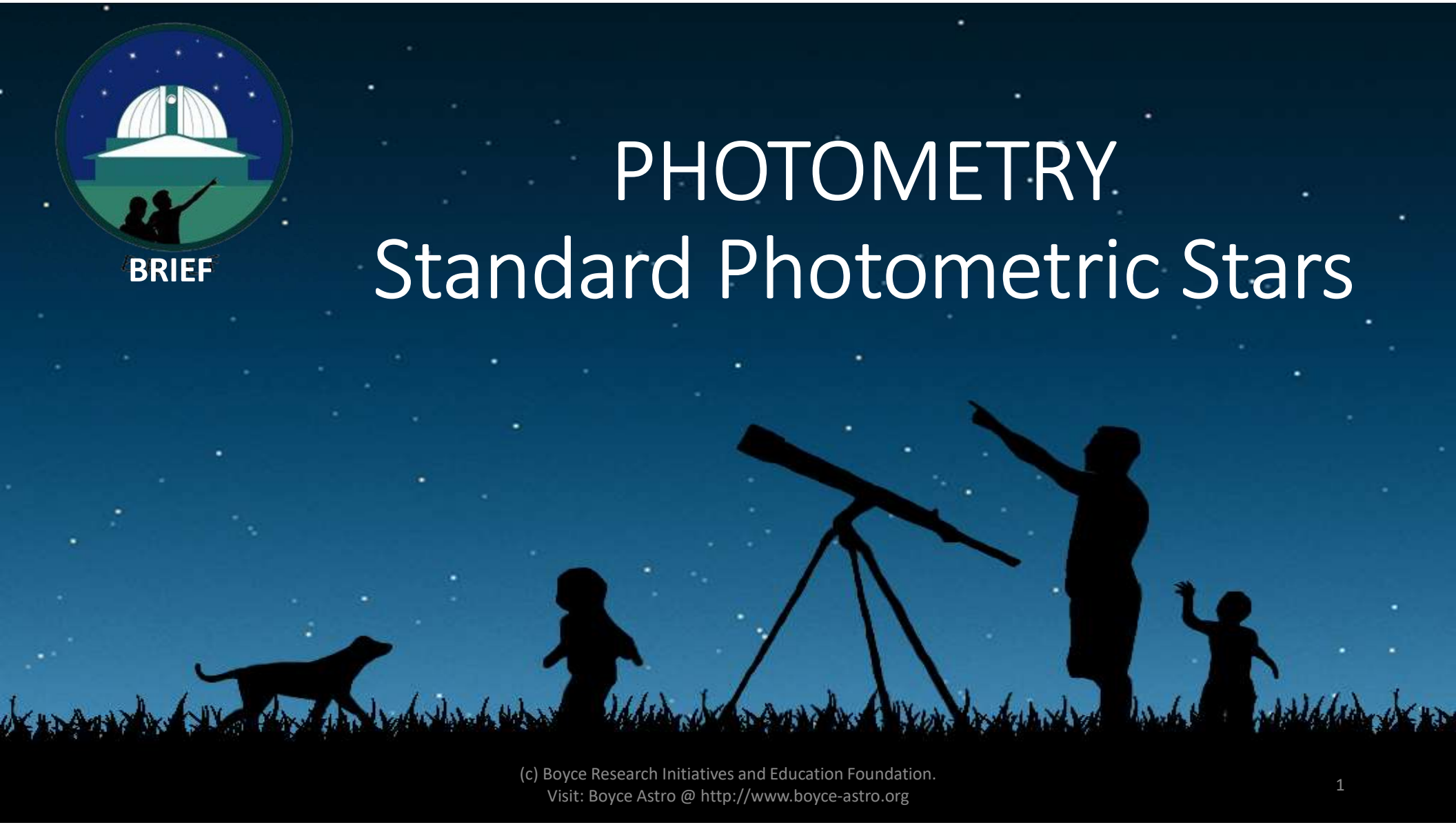
BRIEF

# PHOTOMETRY
# Standard Photometric Stars



**Overview**

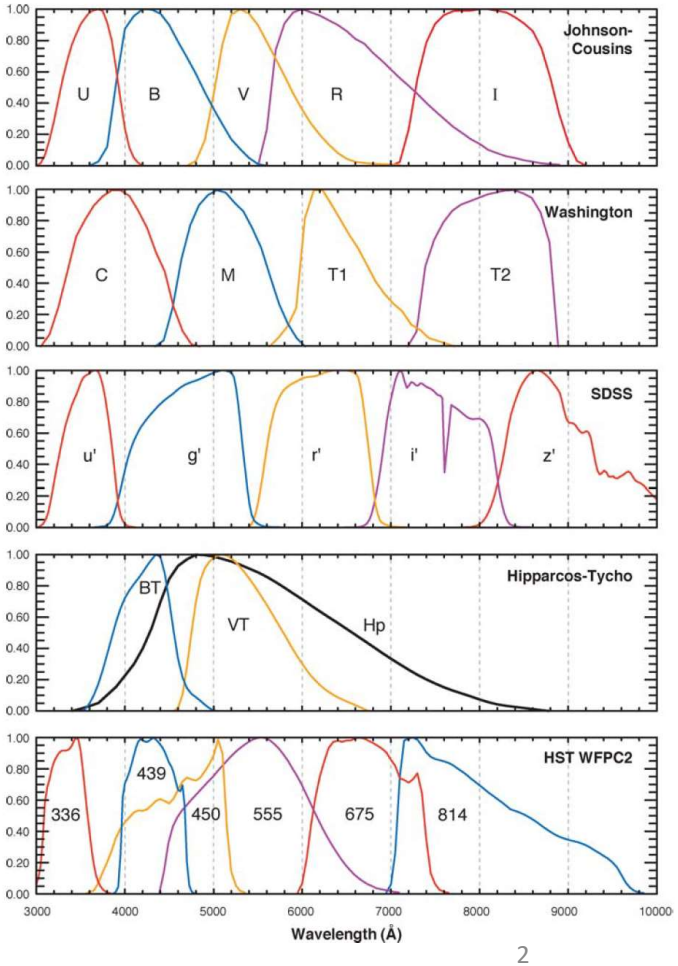
The central function of Photometry is accurate measurement of an object, typically a star, in terms of its brightness either overall magnitude/flux by dividing the flux into varying bands of the Electromagnetic Spectrum.

Whatever your location is on the Earth, you use a defined measurement system to determine the length of varying objects: Imperial and Metric.

When measuring stellar flux, what do you perform measurements and analysis against? This becomes the ultimate question so that there aren't multiple different measurements for a singular object.

Standard Photometric Stars provide a means to, not only calibrate your photometric system, but give a common "yardstick" from which all measurements can be compared.

IMPORTANT: This focuses on standard stars, not standard filter types.



**What is a Standard Star**

Photometric-standard stars are stars that have had their light output in various passbands of photometric system measured very carefully.

Thus the flux measured through your imaging system can be compared to a photometric-standard star to determine the exact brightness, or stellar magnitude, of the object and to calibrate your imaging system. From this you can develop Transform Coefficients.

Use such stars if your science goal requires a calibrated measurement of a flux or surface brightness of a particular object. Doing so places your project on a standardized scale that is both repeatable by others and is standardized against a meaningful scale.

Selection of standard stars will have to span the range of colors of your target and need to be observed them over a range of airmasses that will cover the target you will measure.

It is best to observe at least a dozen standards with a SNR>100 without saturating the CCD. The fainter stars will require longer exposures; therefore it may be best to use the brighter standards when possible.

**Standard Star Sets**

Landolt:

Arlo Landolt measured a number of stars using the UBVRI filter set. The list of primary standards can be found here: http://adsbit.harvard.edu/cgi-bin/nph-iarticle_query?bibcode=1983AJ.....88..439L.

There is a second list of fainter standards with V magnitudes between 11.5 and 16.0 in fields close to the primary standards: http://adsbit.harvard.edu/cgi-bin/nph-iarticle_query?bibcode=1992AJ....104..340L

APASS: AAVSO Photometric All-Sky Survey

The AAVSO all-sky photometric survey was conducted in five filters: Johnson B and V, plus Sloan g', r', i'.

The magnitude ranges are from 7 to 17$^{th}$.

**Landolt Stars**

In 1973, Landolt published a list of stars carefully transformed to the Johnson UBV system. He extended that list to include stars in the Cousins RC and IC bands in 1983. This was further refined in 1992.

This includes fields near the celestial equator as well as regions farther north and south of the equator.

The Landolt catalog has become the de facto standard for transforming to the $UBVR_CI_C$ system.

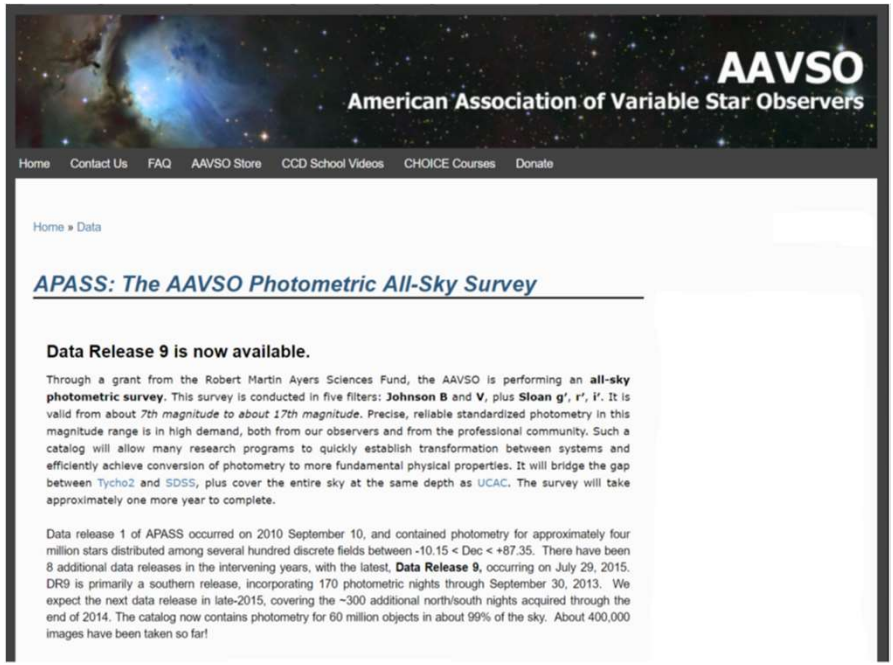
Table 2. *UBVRI* Photometry of Standard Stars.

| | | | | | | | | | | | Mean Error of the Mean | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Star (1) | $\alpha$ (J2000.0) (2) | $\delta$ (J2000.0) (3) | $V$ (4) | $B-V$ (5) | $U-B$ (6) | $V-R$ (7) | $R-I$ (8) | $V-I$ (9) | $n$ (10) | $m$ (11) | $V$ (12) | $B-V$ (13) | $U-B$ (14) | $V-R$ (15) | $R-I$ (16) | $V-I$ (17) |
| TPhe I | 00 30 04.593 | −46 28 10.17 | 14.820 | +0.764 | +0.338 | +0.422 | +0.395 | +0.817 | 25 | 13 | 0.0026 | 0.0032 | 0.0072 | 0.0036 | 0.0098 | 0.0110 |
| TPhe A | 00 30 09.594 | −46 31 28.91 | 14.651 | +0.793 | +0.380 | +0.435 | +0.405 | +0.841 | 29 | 12 | 0.0028 | 0.0046 | 0.0071 | 0.0019 | 0.0035 | 0.0032 |
| TPhe H | 00 30 09.683 | −46 27 24.30 | 14.942 | +0.740 | +0.225 | +0.425 | +0.425 | +0.851 | 23 | 12 | 0.0029 | 0.0029 | 0.0071 | 0.0035 | 0.0077 | 0.0098 |
| TPhe B | 00 30 16.313 | −46 27 58.57 | 12.334 | +0.405 | +0.156 | +0.262 | +0.271 | +0.535 | 29 | 17 | 0.0115 | 0.0026 | 0.0039 | 0.0020 | 0.0019 | 0.0035 |
| TPhe C | 00 30 16.98 | −46 32 21.4 | 14.376 | −0.298 | −1.217 | −0.148 | −0.211 | −0.360 | 39 | 23 | 0.0022 | 0.0024 | 0.0043 | 0.0038 | 0.0133 | 0.0149 |
| TPhe D | 00 30 18.342 | −46 31 19.85 | 13.118 | +1.551 | +1.871 | +0.849 | +0.810 | +1.663 | 37 | 23 | 0.0033 | 0.0030 | 0.0118 | 0.0015 | 0.0023 | 0.0030 |
| TPhe E | 00 30 19.768 | −46 24 35.60 | 11.631 | +0.443 | −0.103 | +0.276 | +0.283 | +0.564 | 38 | 10 | 0.0017 | 0.0013 | 0.0025 | 0.0007 | 0.0016 | 0.0020 |
| TPhe J | 00 30 23.02 | −46 23 51.6 | 13.434 | +1.465 | +1.229 | +0.980 | +1.063 | +2.043 | 28 | 15 | 0.0023 | 0.0043 | 0.0059 | 0.0011 | 0.0015 | 0.0011 |
| TPhe F | 00 30 49.820 | −46 33 24.07 | 12.475 | +0.853 | +0.534 | +0.492 | +0.437 | +0.929 | 19 | 10 | 0.0008 | 0.0024 | 0.0095 | 0.0005 | 0.0014 | 0.0029 |
| TPhe K | 00 30 56.315 | −46 23 26.04 | 12.935 | +0.806 | +0.402 | +0.473 | +0.429 | +0.909 | 2 | 2 | 0.0007 | 0.0007 | 0.0163 | 0.0007 | 0.0001 | 0.0007 |

**APASS**

The AAVSO Photometric All-Sky Survey (APASS) performed an all-sky photometric survey in five filters: Johnson B and V, plus Sloan g', r', i'. The magnitudes range from 7th magnitude to about 17th magnitude.

This catalog helps various research programs establish transformation between different filter systems and achieve conversion of photometry to more fundamental physical properties as it bridges the gap between Tycho2 and SDSS.



**Other Surveys & Standard Systems**

SDSS: Sloan Digital Sky Survey (http:// www.sdss.org/ ) used a set of five filters to survey more than 8000 square degrees of sky. This is the choice for the professional surveys.

2MASS: Two-Micron All-Sky Survey (2MASS) is a system focused on the infrared using the JHK system. The J and K magnitudes are often used to derive magnitudes in rich Milky Way fields, as the stars may suffer extreme reddening due to dust in the line of sight that scatters blue light.

**How to Select Standard Stars**

When selecting a catalog, read the paper/s or other documentation accompanying the catalogue. These will contain details of the limitations, applicability and use of the catalogue which you should be aware of in order to use it effectively.

Do not mix different catalogs within a particular observation program. For example, if you are observing in the Johnson-Morgan system (UBVRI), then Landolt's catalogues are probably the most useful.

The desirable properties for a set of standard stars include the following:

- Range of zenith distances/airmass similar to the catalog stars
- Range of celestial coordinates similar to the catalog stars
- Range of colours and magnitudes similar to the catalog stars

**Observing Standard Stars**

Due to transient variations in atmospheric extinction, it is advisable to regularly monitor the standard stars throughout a night's observing. Passing high clouds can affect this.

A typical strategy might be to start the night's observing with a series of observations of standard stars, covering a range of zenith distances.

These can be used to make a preliminary estimate of the atmospheric extinction. As the night progresses observations of standards are regularly interspersed amongst the observations of catalog stars.

**Summary**

Standard stars place photometric observations on a common platform.

Using these stars allows you to calibrate your photometric system against these well-defined systems and establish Transform Coefficients for each of your filters.

From these coefficients, you can make photometric measurements, apply the coefficient to achieve standardized measurements that are useful for others and other projects.

***Questions?***