Stellar models in Roman filters

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WINGS SIT + Filters Working Group

+ PARSEC-COLIBRI stellar modeling team

A large database of stellar models in Roman filters

- Useful to simulate photometry of nearby fields and distant galaxies (e.g. in WINGS)
- Fairly complete in evolutionary stages (see Martha’s talk)
- Expanded to simulate “unusual” stars (dust-enshrouded, alpha enhanced, fast rotators, variability...)
Filters

- We started in 2017 with 'notional' and then 'proposed' sets of filters
- All previous sets still available (but hidden from users)

- Present set of filters: ‘Roman2021’:
  F062  F087  F106  F129  F146  F158  F184  F213
  SNprism  Grism_1stOrder  Grism_0thOrder
Computing bolometric corrections

Girardi+02: starting from definition of apparent magnitude in a photon-counting device

$$m_{S,\lambda} = -2.5 \log \left( \frac{\int_{\lambda_1}^{\lambda_2} f_\lambda S_\lambda d\lambda}{\int_{\lambda_1}^{\lambda_2} f^0_\lambda S_\lambda d\lambda} \right) + m^0_{S,\lambda},$$

How many photons we count w.r.t. a reference flux (from Vega).

And after introducing absolute magnitudes, the Sun, and extinction, we get a general expression for Bolometric Corrections:

$$BC_{S,\lambda} = M_{\text{bol},\odot} - 2.5 \log \left[ 4\pi (10 \text{ pc})^2 F_{\text{bol}}/L_{\odot} \right]$$

$$+2.5 \log \left( \frac{\int_{\lambda_1}^{\lambda_2} \lambda F_\lambda 10^{-0.4 A_\lambda} S_\lambda d\lambda}{\int_{\lambda_1}^{\lambda_2} \lambda f^0_\lambda S_\lambda d\lambda} \right) - m^0_{S,\lambda}$$

A function only of spectral shape
+ filter transmission curve

$$M_\lambda = M_{\text{bol}} - BC(X_i, \log g, \log T_{\text{eff}}),$$

How brighter are stars at 10 pc w.r.t Vega.
Large grid of \( \text{F}_\lambda \) in \( \log g \times \text{Teff} \times [\text{Fe/H}] \)

YBC (Chen+19)
Spectral library

Large grid of $F_{\lambda}$ in $\log g \times \text{Teff} \times [\text{Fe/H}]$

YBC (Chen+19)
Extinction is applied star-by-star, using O'Donnell+Cardelli’s extinction curve with Rv=3.1

In practice, compute large tables of extinction coefficients, then interpolate:

\[
\frac{A_{\lambda}}{A_V} = \frac{BC_{S_{\lambda}}(A_V) - BC_{S_{\lambda}}(0)}{A_V}.
\]

- **Extinction coefficients** vary with Teff and with Av itself
- In Roman, variation is quite modest, *but for F062 filter*
- Variation is important in many other cases (e.g. Gaia G band, GALEX UV filters,...)
BCs are primarily to complement PARSEC-COLIBRI isochrones -- but can be applied to any set of models:

- Masses between 0.1 and 350 Msun
- Metallicities between -2.3 and +0.4 dex
- C and N-rich models for TP-AGB stars -- with circumstellar dust and numbers calibrated on data! (Pastorelli+19+20)

Some extensions not completely released, or not organized enough:

- White dwarfs, interacting binaries (Dal Tio+21)
- Fast-rotating stars (Costa+19ab, Girardi+20, Thanh+21)
Isochrones in Roman system (Vegamag)

Easily retrievable from http://stev.oapd.inaf.it/cmd
The PARSEC-COLIBRI database

Isochrones (and their predicted star counts) being constantly tested/improved with multiband data of LG galaxies

Babusieaux+18

Mazzi+21
VISTA LMC data

Pastorelli+20
SAGE LMC
Web interfaces

http://stev.oapd.inaf.it/cmd - isochrones in >40 systems

http://stev.oapd.inaf.it/YBC - BC tables
TRILEGAL model for MW foreground

http://stev.oapd.inaf.it/trilegal - expected MW population
Summary

Tools to model stars in Roman filters + any other photometric system
- BCs and isochrones are publicly available
- Used by WINGS to simulate nearby galaxies with STIPS
- Implemented in MATCH -- CMD-fitting software to derive SFHs

Quality depends on adopted spectral libraries -- but we are keeping the best ones!

Ongoing extensions: Non-scaled solar composition, dusty AGBs, rapidly-rotating stars, LPV light curves, limb darkening for transits, etc...