



Automatic procedure for deriving open cluster metallicities

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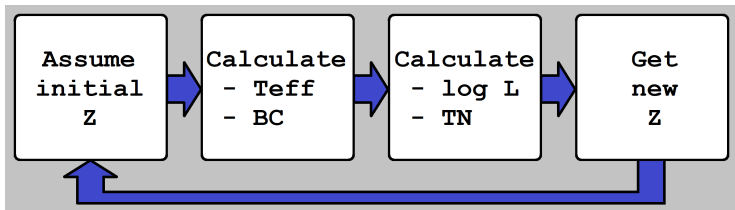
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Method Description

Our focus: studying metallicities of star clusters using the method from [1]

- applicable to any photometric system
- iterative method, input requires photometric data (colour and brightness), distance, reddening
- can be summarised in four main steps:



$$T_N = \log T_{\text{eff}} - \log T_{\text{eff, ZAMS}} | z_{\odot}$$

- used in several studies of open clusters [1][2][3], so far used only in Johnson system, method applied manually

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Together with Ernst Paunzen, we are working on an automatisisation of the described method

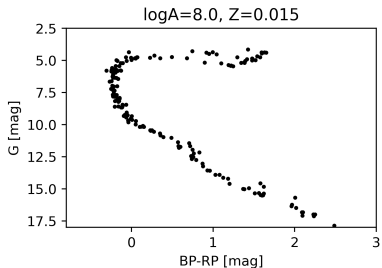
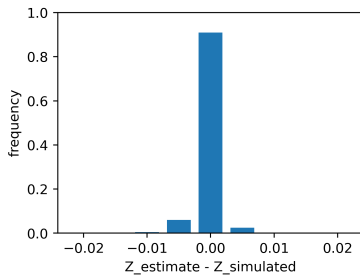
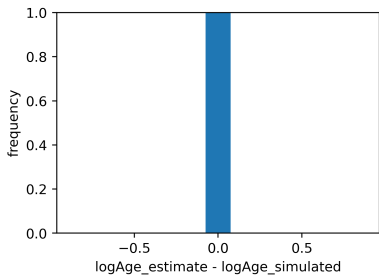
- we have downloaded the isochrone grids from `stev.oapd.inaf.it/cgi-bin/cmd_3.5` [4]
 - $Z_{\min} = 0.005, Z_{\max} = 0.040, Z_{\text{step}} = 0.005$
 - $\log \text{Age}_{\min} = 6.6, \log \text{Age}_{\max} = 9.4, \log \text{Age}_{\text{step}} = 0.1$
- procedure can automatically extract the metallicities (and ages) of star clusters
- extended to other photometric systems
 - Johnson: $V, (B - V)$
 - 2MASS: $J, (J - K_S)$
 - Gaia: $G, (B_p - R_p)$
- extended the range of applicable colour-values toward higher temperatures (starting from about 3 500 K up to about 25 000 K)
- procedure has been tested and is applicable to the full range of metallicities

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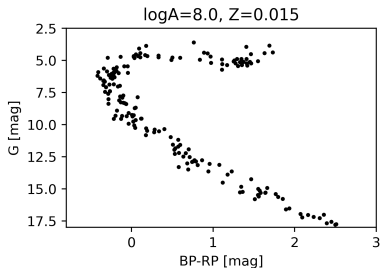
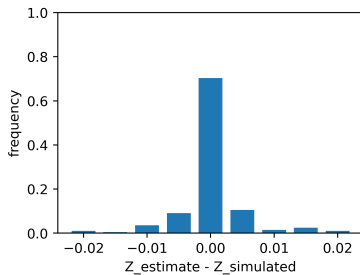
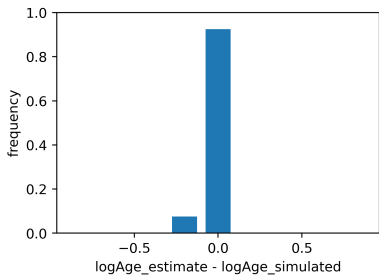
Possible issues

- binaries (shifts results toward higher Z)
- giants (may require artificial weights and separate calibrations)
- pre-main-sequence (currently unsolvable)
- star-forming regions (differential extinction)

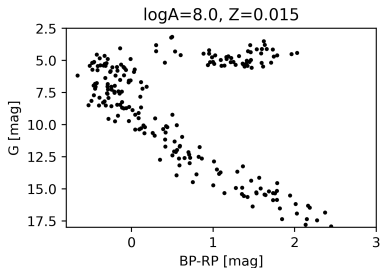
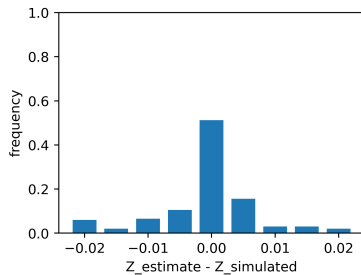
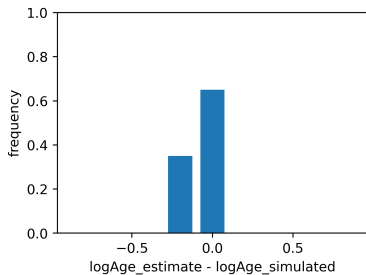
Test Case: Synthetic Clusters



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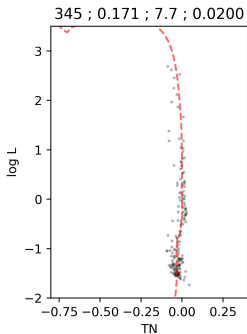
Test Case: Synthetic Clusters



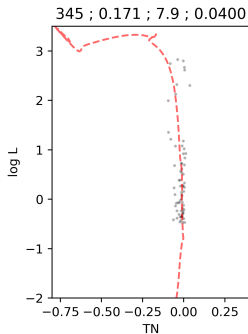
Test Case: Pöhl & Paunzen (2010) – IC 4665

$d = 352$ pc, $E(B - V) = 0.174$ mag, $\log \text{Age} = 7.634$, $Z = 0.022$

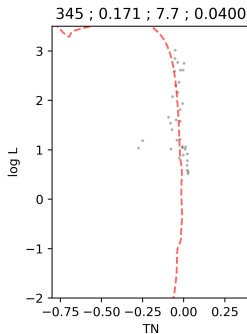
Gaia [5]



2MASS [6]



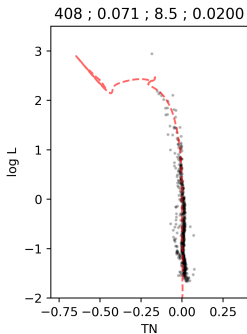
Johnson [7]



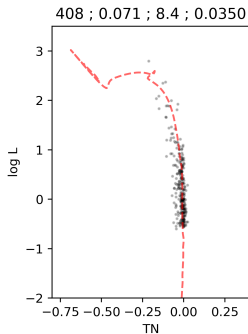
Test Case: Pöhl & Paunzen (2010) – NGC 2516

$d = 360$ pc, $E(B - V) = 0.112$ mag, $\log \text{Age} = 8.150$, $Z = 0.015$

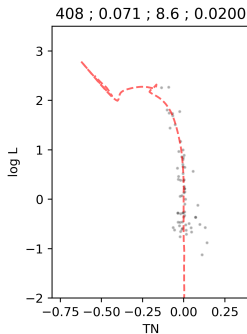
Gaia [5]



2MASS [6]



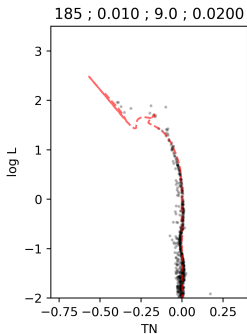
Johnson [7]



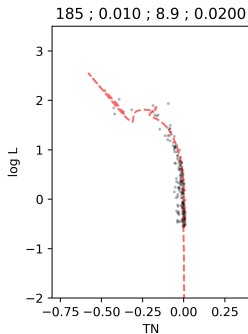
Test Case: Pöhl & Paunzen (2010) – NGC 2632

$d = 171$ pc, $E(B - V) = 0.027$ mag, $\log \text{Age} = 8.720$, $Z = 0.028$

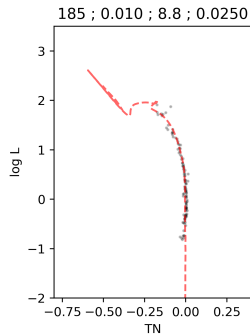
Gaia [5]



2MASS [6]

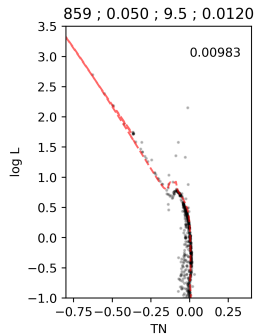
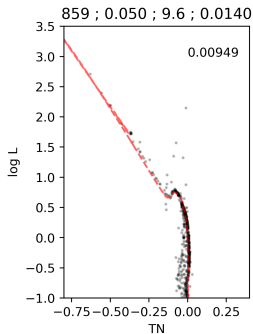
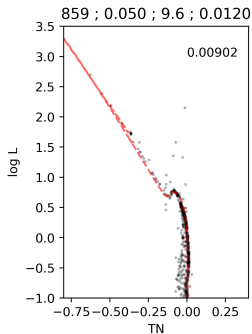


Johnson [7]



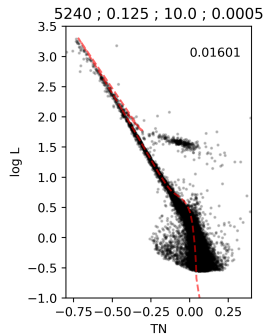
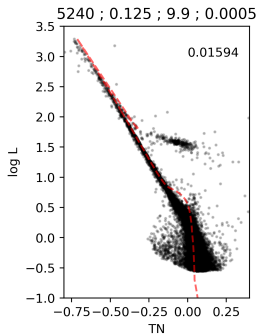
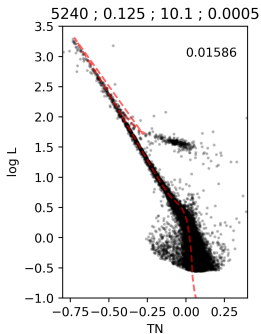
Test Case: M 67

Photometric system: Gaia (data from [5])



Test Case: ω Centauri

Photometric system: Gaia (data from [8])



Summary

- automatic procedure for finding metallicities (+ ages + possibly the other two cluster parameters)
- the procedure is applicable for a wide range of cluster ages and metallicities
- applicable to any photometric system for which the isochrones are available (useful when the Gaia DR3 is made public)
- the code will be made publicly available at the end of the project
- if anybody is interested in a collaboration, we are always looking for good ideas where the procedure could be of use

Thank You for Your Attention!

- [1] Pöhl, H., Paunzen, E., 2010, *A statistical method to determine open cluster metallicities*, A&A, 514, 81
- [2] Netopil, M., Paunzen, E., 2013, *Towards a photometric metallicity scale for open clusters*, A&A, 557, 10
- [3] Netopil, M., Paunzen, E., Heiter, U., Soubiran, C., 2016, *On the metallicity of open clusters. III. Homogenised sample*, A&A, 585, 150
- [4] stev.oapd.inaf.it/cgi-bin/cmd_3.5
- [5] Cantat-Gaudin, T., Anders, F., 2020, *Clusters and mirages: cataloguing stellar aggregates in the Milky Way*, A&A, 633, 99
- [6] Skrutskie, M. F., Cutri, R. M., Stiening, R., et al., 2006, *The Two Micron All Sky Survey (2MASS)*, AJ, 131, 1163
- [7] webda.physics.muni.cz
- [8] Gaia Collaboration et al., 2018, *Gaia Data Release 2. Kinematics of globular clusters and dwarf galaxies around the Milky Way*, A&A, 616, 12