II Международная дистанционная астрономическая олимпиада
II International Remote Astronomy Olympiad
Италия, Матера 15-24. X. 2022 Matera, Italy

Practical round. Problems to solve

13. Differential rotation of the Sun

The Sun is characterized by a differential rotation, i.e. the angular velocity decreases with increased latitude.

When the weather conditions permit, daily observations of the photosphere are carried out at the INAF–Catania Solar Telescope by a Cooke refractor (150 mm / 2230 mm). These observations allow us to measure the location of the barycenter of the sunspot groups visible on the solar disc.

In the tables 13.1. – 13.4. (see supplement materials) we report the National Oceanographic and Atmospheric Administration (NOAA) sunspot group numbers (NOAA Nr.), which identify each group, and the corresponding longitudes (λ, in degrees) and latitudes (φ, in degrees) for some available observation days.

13.1. Assuming that the observations have been done every day at 08:30 UT and using the sunspot groups as traces for the solar rotation, build the graph containing the average rotation velocity (degree/day) vs latitude for the following North latitudes: 08N, 16N, 20N and 28N.

13.2. Analogously, build a similar graph for the Southern hemisphere using the following latitudes: 06S, 10S, 18S and 27S.

13.3. Assume that the differential rotation of the Sun may be described by a simple linear regression between the velocity (V) and the latitude (L):

$$V(L) = B \cdot L + A$$

with B angular coefficient and A constant term, respectively. Determine the slopes of the linear regression for both hemispheres by the best fit method.

13.4. How much is rotational velocity at the equator if you use only the sunspot groups observed in the southern hemisphere?

13.5. In which hemisphere the rotational velocity varies faster with the latitudes? (Answer "N" for Northern hemisphere or "S" for Southern one.) Prove your answer by numerical values obtained in your calculations).

Note: problems for Group α – 13, 14, for Group β – 14, 15, for Group γ – 13, 14, 15.

Practical round. Problems to solve

14. Hubble parameter

Estimate the Hubble parameter with type Ia Supernovae (SN Ia).

The most accurate measurements of the Hubble parameter H_0 are based on observations of type Ia Supernovae in addition to information of the distances to nearby galaxies using Cepheid stars. Although this study initially started from the optical bands, it was found that the use of near infrared (in the J band) involves considering far fewer corrections. Nine neighbouring galaxies are used as near infrared calibrators whose distances, as distance modulus, are known through the cepheids and in addition in that galaxies SN Ia have been observed:

The data is presented in the Table 14.1 (neighbouring galaxies, columns: supernova Ia, host galaxy, m_J (J magnitude), distance modulus by cepheids) and Table 14.2 (more distant galaxies, columns: supernova Ia, m_J (J magnitude), host galaxy, redshift z).

14.1. Using Table 14.1, draw the graph "distance module vs magnitude J".

14.2. Apparent magnitude, absolute magnitude, Hubble parameter H_0, and redshift z, are connected by a formula of the following form:

$$m_J - M_J = A \cdot \log(H_0) + B \cdot \log(z) + C;$$

Calculate the values of coefficients A, B and C.

14.3. Using the data in Table 14.2 (galaxies with a large distance), draw the necessary graph and, using this graph ...

14.4. ... get the average value obtained for H_0, calculating it for 4 supernovae using the formula obtained above.

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Practical round. Problems to solve

15. Evolutionary phases of stars

The evolutionary phases of the stars in the HR Diagram

In stellar evolution, observational data are often compared with theoretical ones through the use of the HR diagram. The table 15 shows some selected and observed stars (from A to M) of a globular cluster.

15.1. Using the grid provided (in supplement materials) put the observed stars in the plane (m_B–m_V) vs m_V.

15.2. Comparing them with the theoretical isochrones (stars of the same age but of different mass, see graph in supplement materials) indicate for the stars A, B, C and G their evolutionary phase. To avoid writing words, use the following abbreviations:

- PMS – for Pre-Main Sequence
- MS – for Main Sequence
- TO – for Turn-off
- RGB – for Red Giant Branch
- HB – for Horizontal Branch
- PN – for Planetary Nebula
- WD – for White Dwarf

15.3. Estimate the distance module and the age of the cluster.

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Practical round

13.1. **01.10.2018.**

NOAA Nr.	φ	λ
12192	03 N	18 E
12193	08 N	02 E
12194	12 S	45 E
12195	16 N	37 E
12197	06 S	35 E
12198	10 S	18 E
12199	20 N	47E
12200	18 S	02 W
12201	27 S	12 W
12202	28 N	05 E

13.2. **02.10.2018.**

NOAA Nr.	φ	λ
12192	03 N	04 E
12193	08 N	12 W
12194	12 S	32 E
12195	16 N	23 E
12197	06 S	20 E
12198	10 S	04 E
12199	20 N	34 E
12200	18 S	11 W
12201	27 S	23 W
12202	28 N	07 W

13.3. **03.10.2018.**

NOAA Nr.	φ	λ
12192	03 N	11 W
12193	08 N	26 W
12194	12 S	18 E
12195	16 N	09 E
12197	06 S	05 E
12198	10 S	11 W
12199	20 N	21 E
12200	18 S	23 W
12201	27 S	35 W
12202	28 N	20 W

13.4. **05.10.2018.**

NOAA Nr.	φ	λ
12192	03 N	40 W
12193	08 N	55 W
12194	12 S	10 W
12195	16 N	16 W
12197	06 S	24 W
12198	10 S	39 W
12199	20 N	06 W
12200	18 S	48 W
12201	27 S	59 W
12202	28 N	44 W

Practical round

14.1.

SN Ia	HG	m_J	DM
SN2001el	NGC1448	12.837	31.311
SN2002fk	NGC1309	13.749	32.523
SN2003du	UGC9391	14.325	32.919
SN2005cf	NGC5917	13.791	32.263
SN2007af	NGC5584	13.446	31.786
SN2011by	NGC3972	13.218	31.587
SN2011fe	M101	10.464	29.135
SN2012cg	NGC4424	12.285	31.08
SN2015F	NGC2442	13.081	31.511

14.2.

SN Ia	m_J	HG	z
SN2004eo	15.5	NGC6928	0.015
SN2007bd	17.1	UGC4455	0.032
SN2009ad	16.9	UGC3236	0.029
SN2001ao	14.9	IC2973	0.012

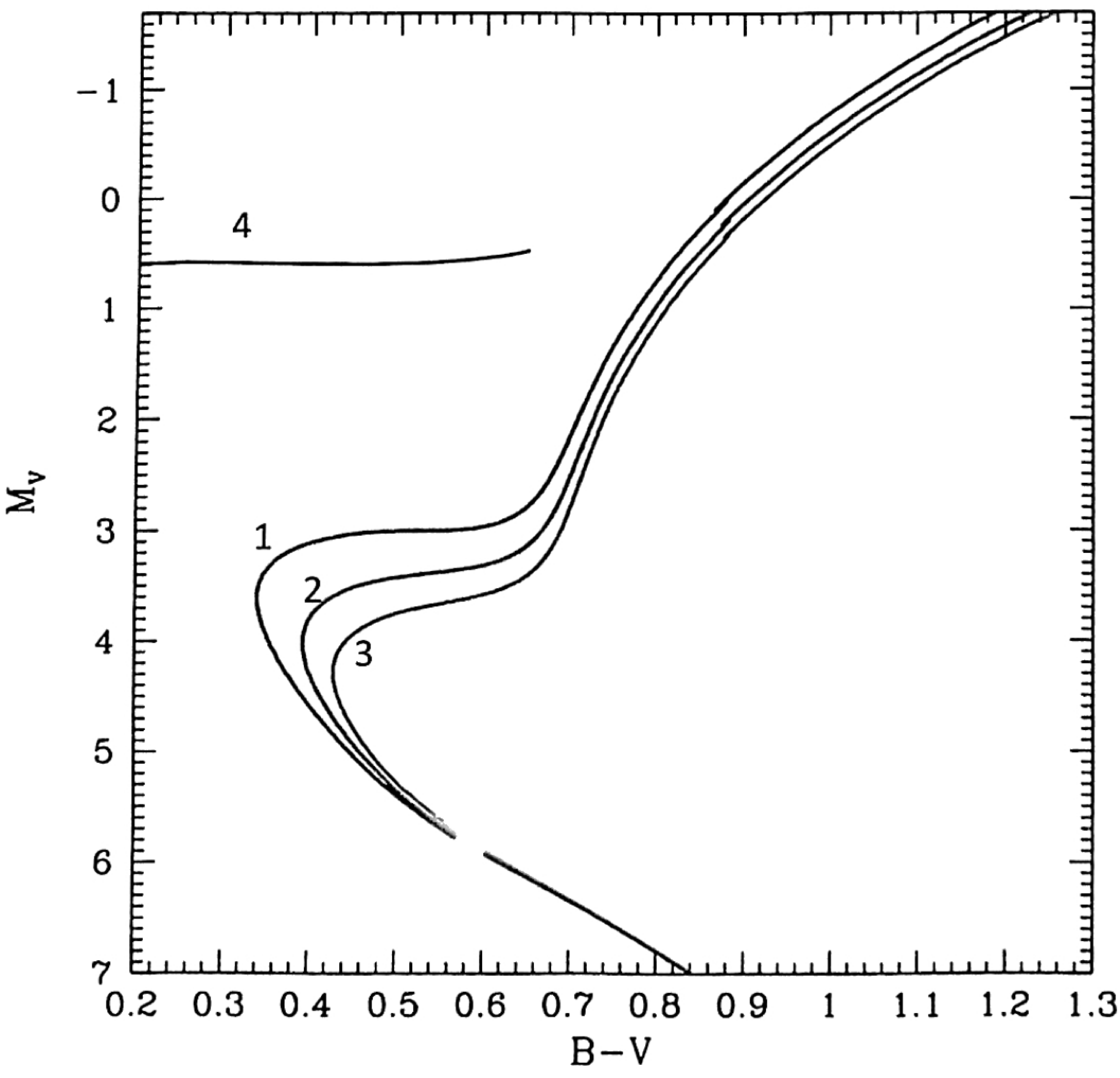
Practical round

15.

OBS	m_b	m_v
A	15,182	14,266
B	20,625	20,059
C	18,709	18,316
D	21,340	20,645

OBS	m_b	m_v
E	22,118	21,285
F	18,274	17,739
G	15,394	14,837
H	15,675	14,828

OBS	m_b	m_v
I	17,436	16,731
L	20,286	19,772
M	16,100	15,301



Code of participant	код участника

15.