Stars and their variability observed from space
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CEPHEIDS NEAR AND FAR

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Abstract. Cepheid variable stars play a fundamental role in astronomy because they are standard candles for calibrating the cosmic distance scale via the period-luminosity relationship. As of October 2019, Cepheids have been discovered in 97 galaxies beyond the Milky Way. The total number of known Cepheid variable stars now exceeds 20 000 (not counting the newly discovered ones announced in Gaia DR2). In this paper we presented our online database maintained at the web site of the Konkoly Observatory*.

Keywords: Stars: variables: Cepheids, Astronomical databases: miscellaneous, Galaxies: statistics, Stars: statistics, Galaxy: stellar content, (Cosmology:) distance scale

1 Introduction

Cepheid variable stars are pulsating supergiant stars, and are found in the classical instability strip of the Hertzsprung-Russell diagram. The first Cepheids in the Milky Way were discovered in the late 1700s by Pigott (1785) and Goodricke (1786). The first extragalactic Cepheids were discovered by Leavitt (1908). In the last hundred or more years a huge number of Cepheids have been discovered within about 40 Mpc. As their pulsation periods and luminosities are related through the so-called period-luminosity relationship (see Leavitt & Pickering 1912), they constitute the basis of the cosmic distance ladder.

A list of the hosting galaxies, their distance from the Milky Way and the number of known Cepheids (N) they contain is given in Table 1. In Fig. 1 the left panel shows the number of host galaxies as a function of distance. The riht panel indicates that the number of known Cepheids is inversely proportional to the distance of the galaxy; however, this is a selection effect caused by the fact that the discovery of brightness variability depends on the limiting magnitude of the photometry. The most distant galaxy known to host Cepheids is at about 40 Mpc from our Galaxy.

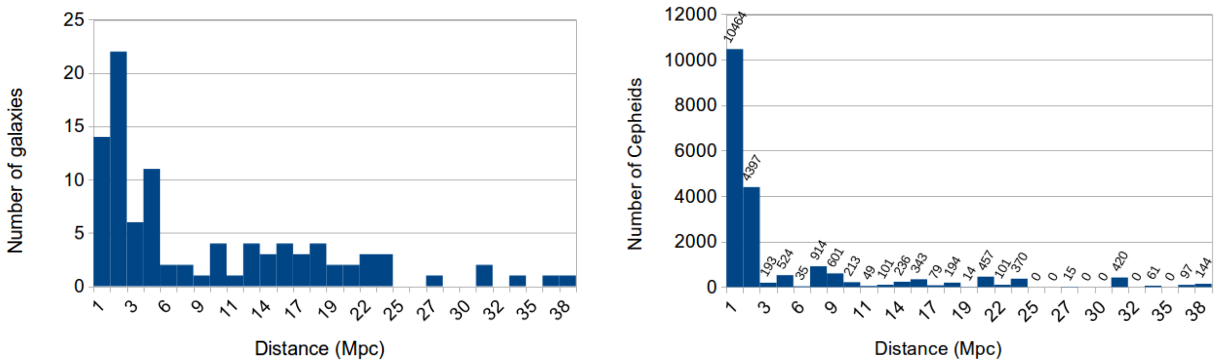

Fig. 1. Left: The number of host galaxies as a function of distance. **Right:** The number of known Cepheids beyond the Milky Way as a function of distance.

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*`https://cepheids.konkoly.hu`

Galaxy	N	Distance (Mpc)	Galaxy	N	Distance (Mpc)	Galaxy	N	Distance (Mpc)
Milky Way	2807		NGC 3370	348	30.03	DDO 155	1	2.42
LMC	5122	0.03	NGC 3447	126	13.48	DDO 187	2	2.20
SMC	5102	0.05	NGC 3621	69	6.74	DDO 193	32	39.83
NGC 55	134	2.14	NGC 3627 (M66)	68	9.50	DDO 210	75	0.98
NGC 147	7	0.79	NGC 3972	78	12.87	DDO 216	39	0.92
NGC 185	13	0.63	NGC 3982	72	20.87	IC 10	5	0.67
NGC 205 (M110)	7	0.82	NGC 4038	58	13.79	IC 342	24	3.28
NGC 224 (M31)	2686	0.77	NGC 4258 (M106)	601	8.00	IC 1613	209	0.73
NGC 247	26	3.37	NGC 4321 (M100)	52	16.85	IC 4182	28	5.21
NGC 300	151	1.86	NGC 4395	11	4.29	Andromeda II	1	0.68
NGC 598 (M33)	747	0.84	NGC 4414	11	19.09	Andromeda III	5	0.75
NGC 925	80	9.28	NGC 4424	7	5.21	Andromeda VI	6	0.78
NGC 1015	27	36.15	NGC 4496A	95	22.67	Andromeda XIX	8	0.92
NGC 1309	172	36.76	NGC 4527	86	14.98	Andromeda XXI	9	0.86
NGC 1313	26	4.29	NGC 4535	50	16.59	Andromeda XXV	3	0.80
NGC 1326A	17	15.99	NGC 4536	153	14.92	Canes Venatici I	3	0.22
NGC 1365	95	20.83	NGC 4548 (M91)	24	19.30	Carina	22	0.03
NGC 1425	29	21.14	NGC 4571	3	17.77	Cetus	3	0.75
NGC 1448	89	16.85	NGC 4603	61	32.78	Draco	8	0.08
NGC 1637	41	9.19	NGC 4639	64	22.37	Fornax	31	0.14
NGC 2090	34	12.26	NGC 4725	20	12.26	Leo I	12	0.27
NGC 2366	6	3.06	NGC 5128 (Cen A)	51	4.29	Leo II	4	0.21
NGC 2403	17	2.45	NGC 5235 (M83)	112	4.60	Phoenix	24	0.44
NGC 2442	433	20.01	NGC 5253	15	3.34	Sagittarius	1	1.04
NGC 2541	34	12.26	NGC 5457 (M101)	845	6.43	Sculptor	4	3.49
NGC 2841	26	14.09	NGC 5584	212	22.06	Sextans	6	0.09
NGC 3021	72	30.64	NGC 5917	15	26.04	Sextans A	92	1.32
NGC 3031 (M81)	141	3.68	NGC 6822	157	0.49	Sextans B	8	1.36
NGC 3109	120	1.29	NGC 7250	29	15.32	Tucana	6	0.98
NGC 3198	78	14.40	NGC 7331	13	12.26	Ursa Minor	6	0.06
NGC 3319	33	16.24	NGC 7793	17	3.89	Wolf-Lundmark-	61	0.93
NGC 3351 (M95)	49	10.11	Holmberg II	7	3.37	Melotte		
NGC 3368 (M96)	24	9.50	Leo A	156	0.80	I Zwicky 18	3	18.08

Table 1. Numbers of known Cepheids (N) in host galaxies, and the distances of the galaxies (Mpc).

2 Galactic Cepheids

Almost 15% (2807) of the known Cepheid variables have been found in the Milky Way Galaxy (Udalski et al. 2018). The distribution of Galactic Cepheids is shown in Fig. 2; however, that distribution does not include the newly discovered Cepheids announced in Gaia DR2 [†] (see Gaia Data Release 2 in Gaia Collaboration, Brown et al 2018).

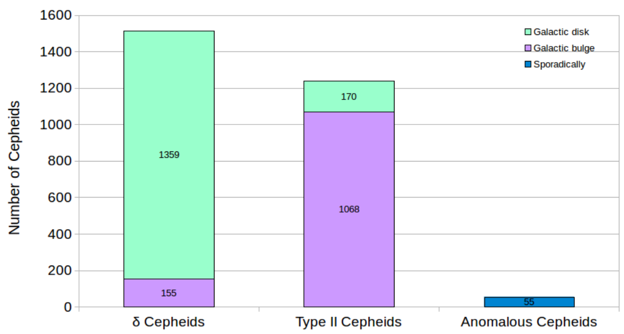

Fig. 2. Location of the known Cepheids in the Milky Way system.

- **δ Cepheids:** 54% (1514) of the Cepheids in the Milky Way are classical Cepheids and are mainly located in the Galactic disk.

[†] https://www.cosmos.esa.int/web/gaia/dr2

- **Type II Cepheids:** 44% (1238) of the Cepheids in the Milky Way are metal-poor type II Cepheids, and are located mainly in the Galactic bulge.
- **Anomalous Cepheids:** 2% (55) of the Cepheids in the Milky Way are anomalous Cepheids, and are located sporadically in the Galaxy.

3 Extragalactic Cepheids

The number of known Cepheid variables as a function of distance is shown in the right panel of Fig. 1. It can easily be seen that almost 75% (∼15000) of the Cepheids beyond the Milky Way are found in the Local Group. More than 51% (10224) of the known extragalactic Cepheid variables are located in the Magellanic Clouds. As to the numbers of known Cepheids, the 10 host galaxies beyond the Milky Way containing the most Cepheidsare listed in Table 2.

Galaxy	N	% of $N_{\rm all}$ [a]	Distance (Mpc)
LMC	5122	25.6	0.03
SMC	5102	25.5	0.05
M31	2686	13.4	0.77
M101	845	4.2	6.43
M33	747	3.7	0.84
M106	601	3	8.00
NGC 2442	433	2.1	20.01
NGC 3370	348	1.7	30.03
NGC 5584	212	1.1	22.06
IC 1613	209	1	0.73

[a] Percentages of the known extragalactic Cepheids: $N/N_{\rm all}$.

Table 2. The ten galaxies beyond the Milky Way containing the largest number of known Cepheids.

4 Conclusion

When investigating the periods of Cepheids in each host galaxy, we found that the more distant the galaxy, the longer the mean value of the period of Cepheids (see Fig. 3). However, that effect can be explained as a selection effect in the way the Cepheids were discovered. According to the period-luminosity relation, the more luminous the Cepheid, the longer its pulsation period. That emphasizes the importance of observing distant galaxies with higher sensitivity in order to search for short-period Cepheids among the fainter stars.

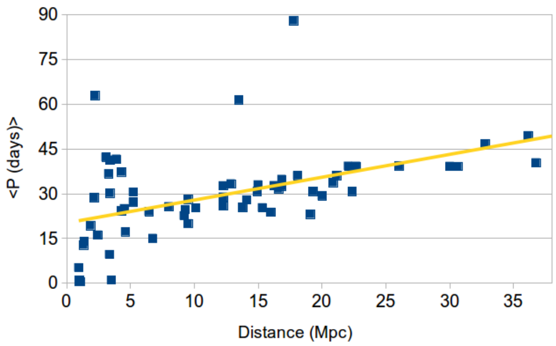

Fig. 3. The distribution of the mean values of periods of Cepheids per galaxy as a function of distance.

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