



Bonatti, Hu, Marcomini

CEPHEIDS

D I S T A N C E D E T E R M I N A T I O N

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A BRIEF INTRODUCTION ON CEPHEIDS



- **Cepheids** are a type of ***variable*** star that undergo ***periodic*** fluctuations in brightness due to their expansion and contraction.
- The key feature of Cepheids is the period-luminosity relation, which links the pulsation period of the star to its intrinsic brightness.
- This relationship allows astronomers to accurately measure the star's ***distance*** by comparing its observed brightness with its true luminosity.

HOW TO FIND THE DISTANCE OF THE GALAXY NGC3198

01

- By analyzing the variation in apparent magnitude of a cepheid whose distance is known over its brightness period we are able to find a relationship that links its absolute magnitude and the log of its period



03

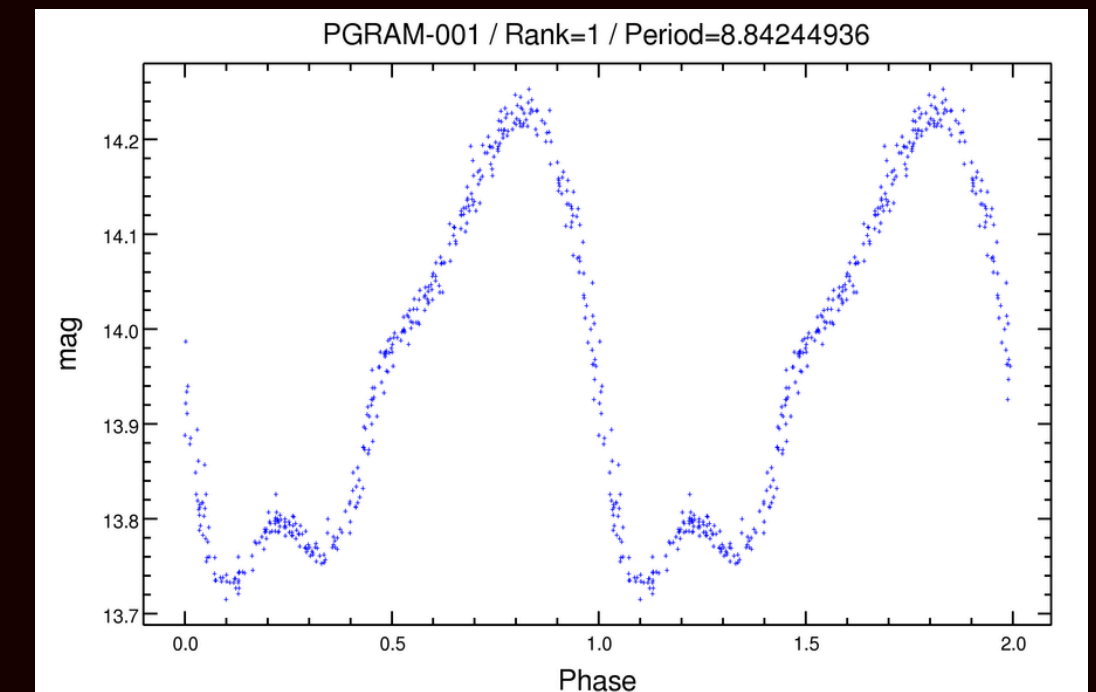
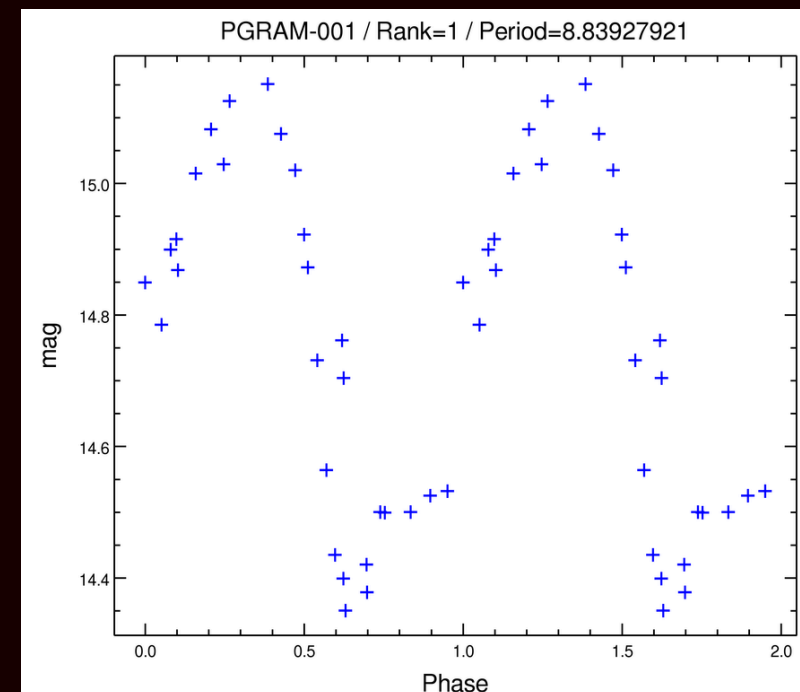
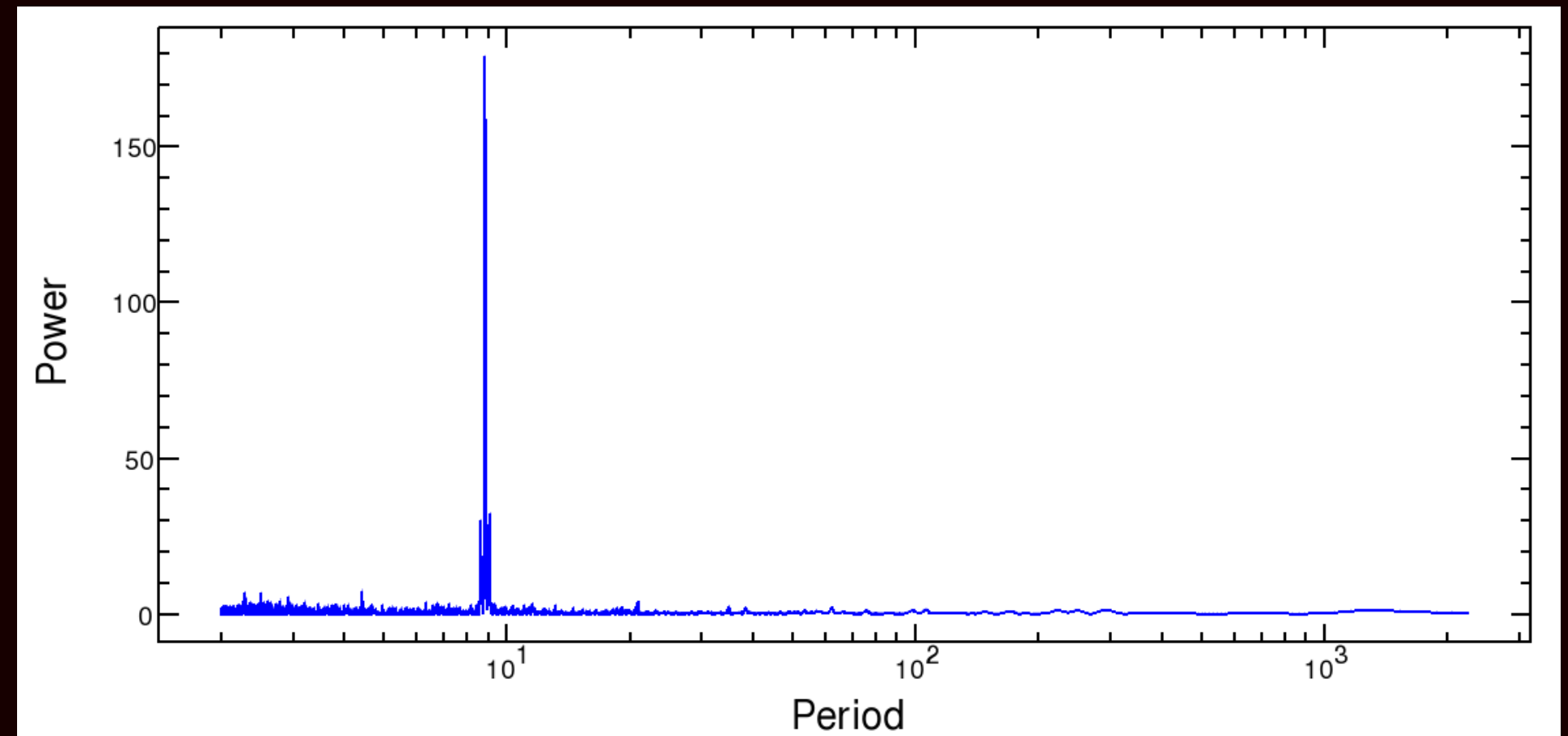
- Ultimately, by plugging the found values in the aforementioned formula we've found the absolute magnitude and successively their distance

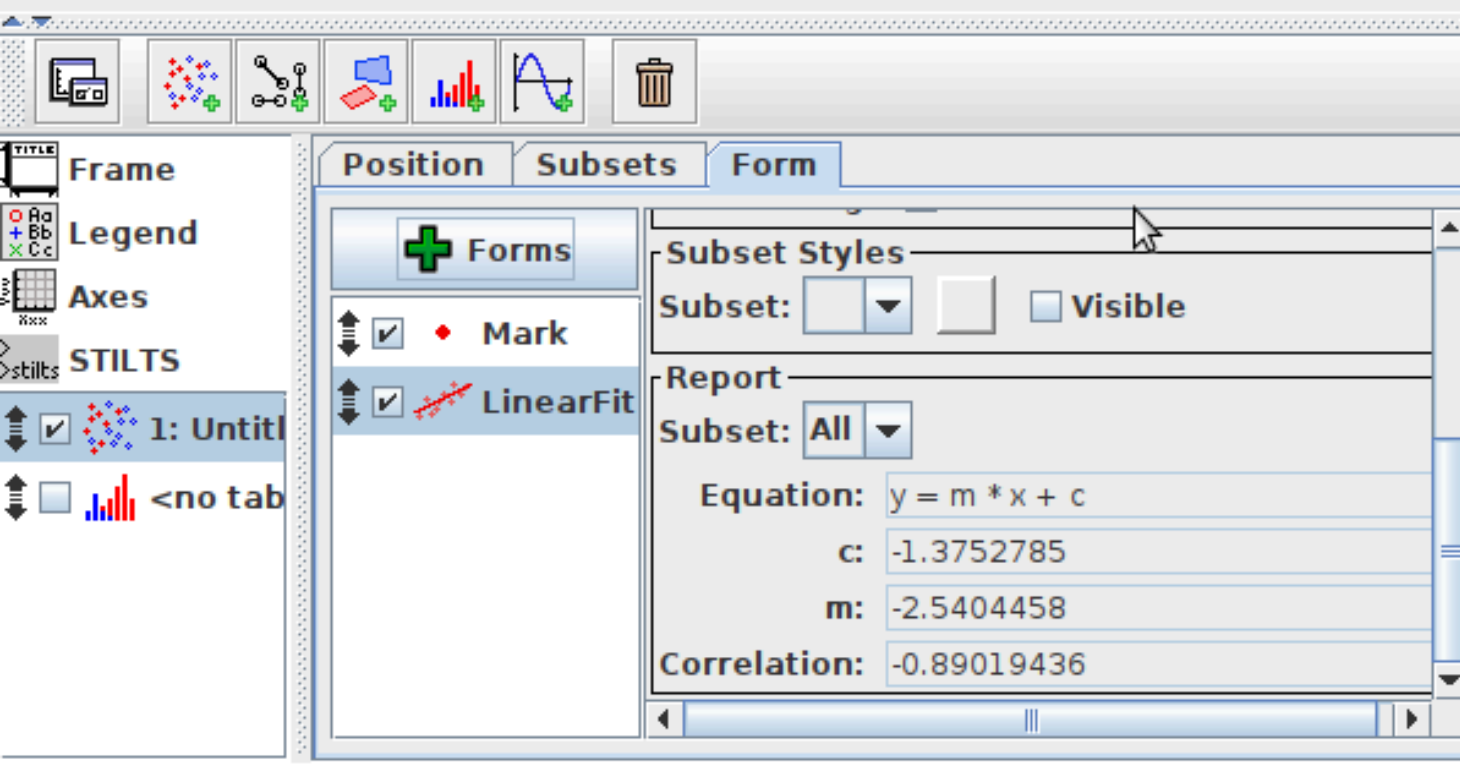
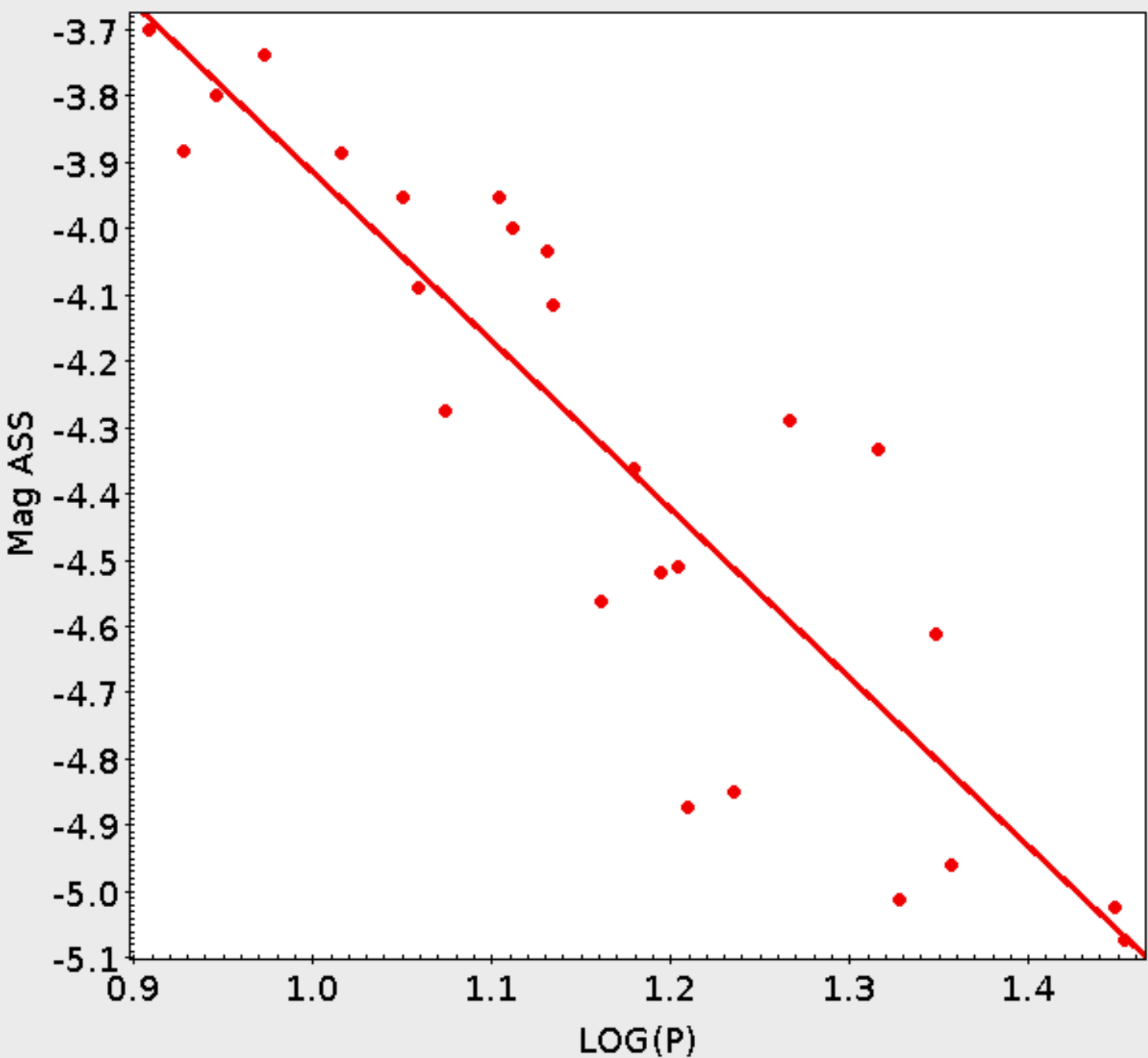
02

- Afterwards we've extracted the values of the apparent magnitude and the periods of some cepheids which belong to ngc3198 from the images collected by Hubble Space Telescope

STUDY OF THE VARIABLE BRIGHTNESS

By plugging the acquired datas in the software “periodogram” we’ve taken into exam the most-likely periods and afterwards it created the graphs underneath.





COMPUTING THE AVERAGE ABSOLUTE MAGNITUDE

01

$$V = 2.5 \log_{10}(2) - 2.5 \log_{10} \left(10^{-\frac{2V_{\max}}{5}} + 10^{-\frac{2V_{\min}}{5}} \right)$$

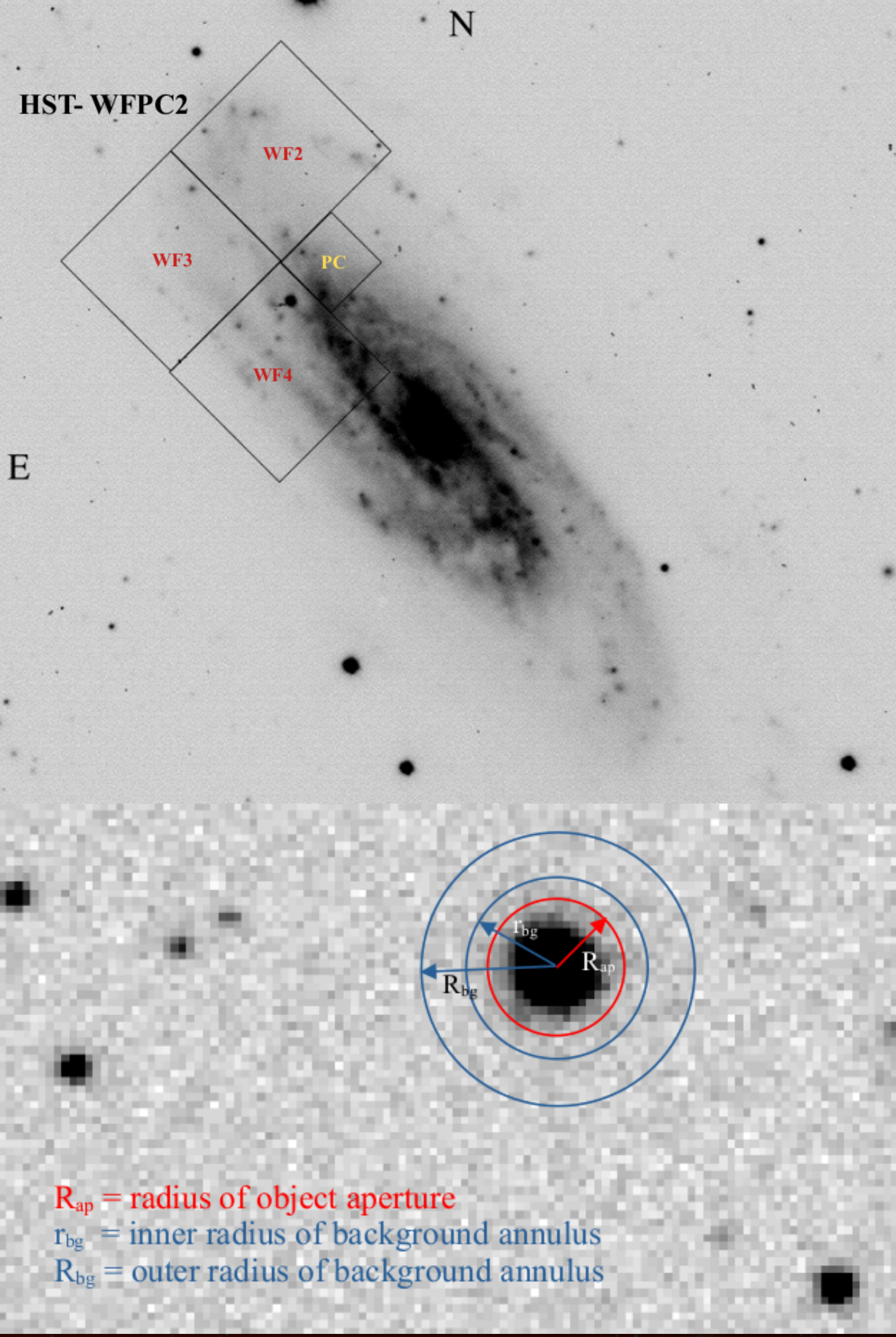
02

$$M_V = V + 5 - 5 \cdot \log_{10}(d)$$

- Where $d = 49,59$ Kpc is the distance of the Large Magellanic Cloud

03

$$M_V = \Sigma \cdot \log_{10}(P) + M_{V,0}$$

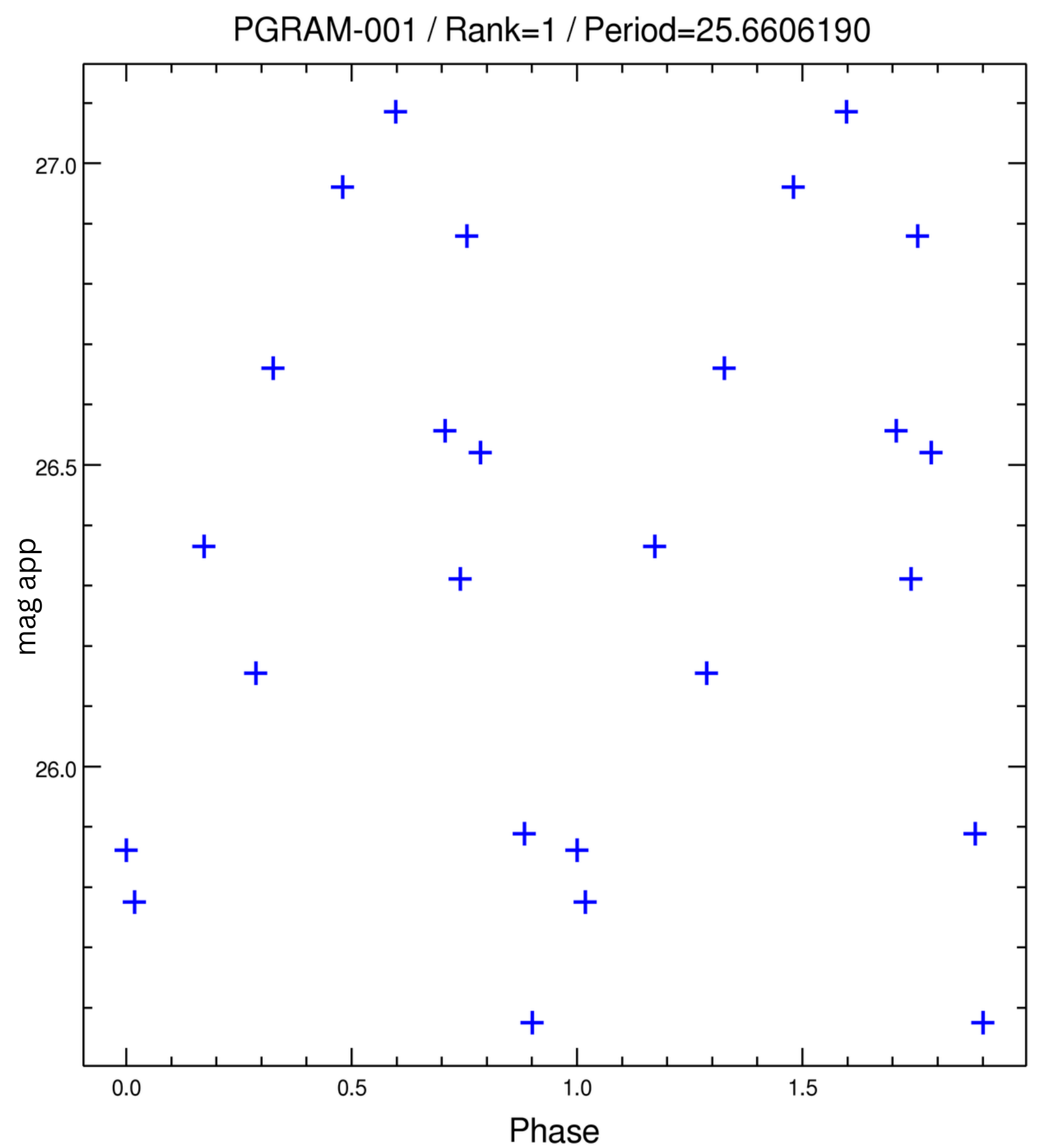
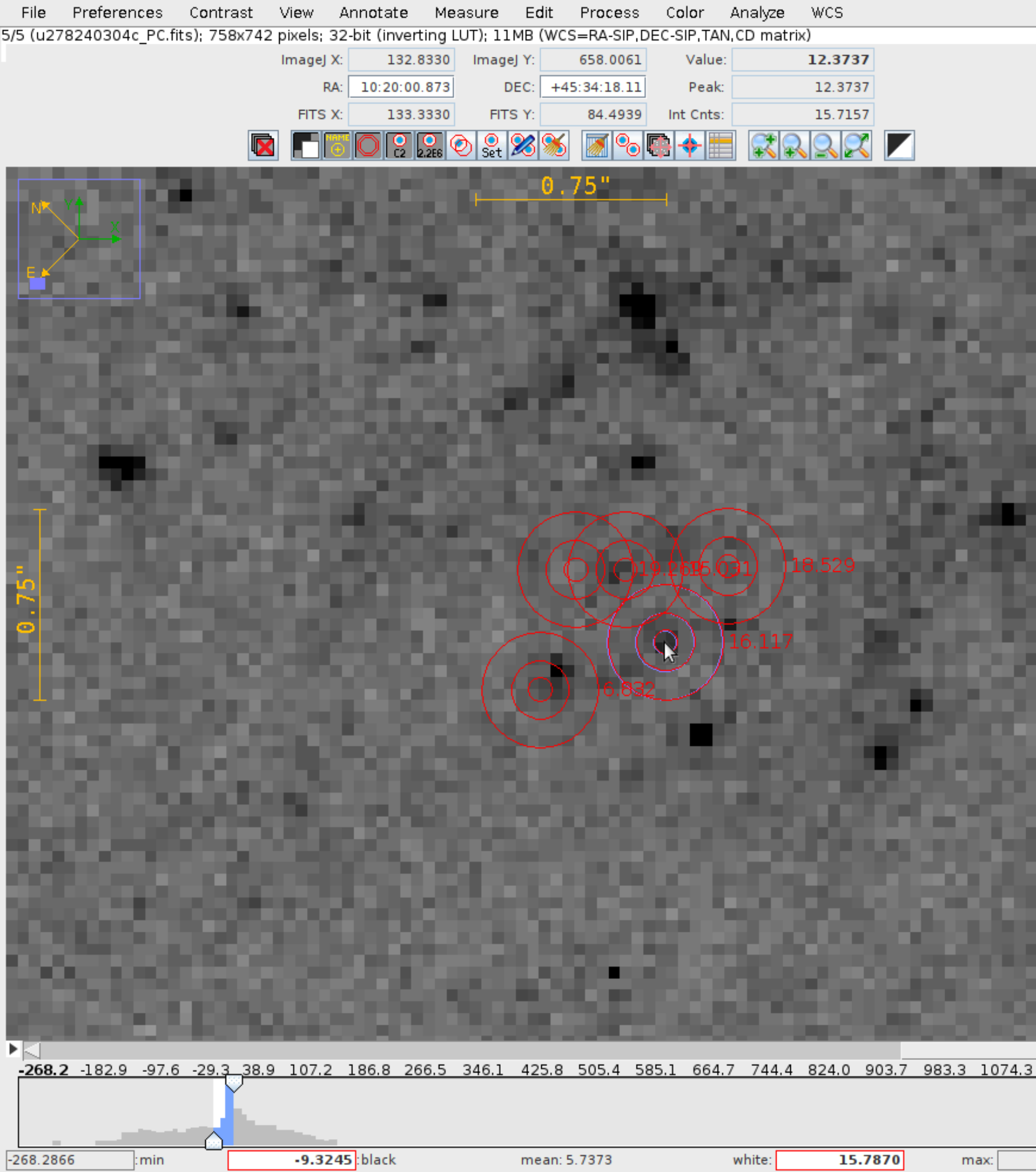


EXTRACTING DATAS FROM IMAGES

from the images gathered by the **Hubble Space Telescope**, by removing the background luminosity of the stars of interest with the tools provided by **AstrolmageJ**, we were able to obtain the apparent magnitudes of our Cepheids

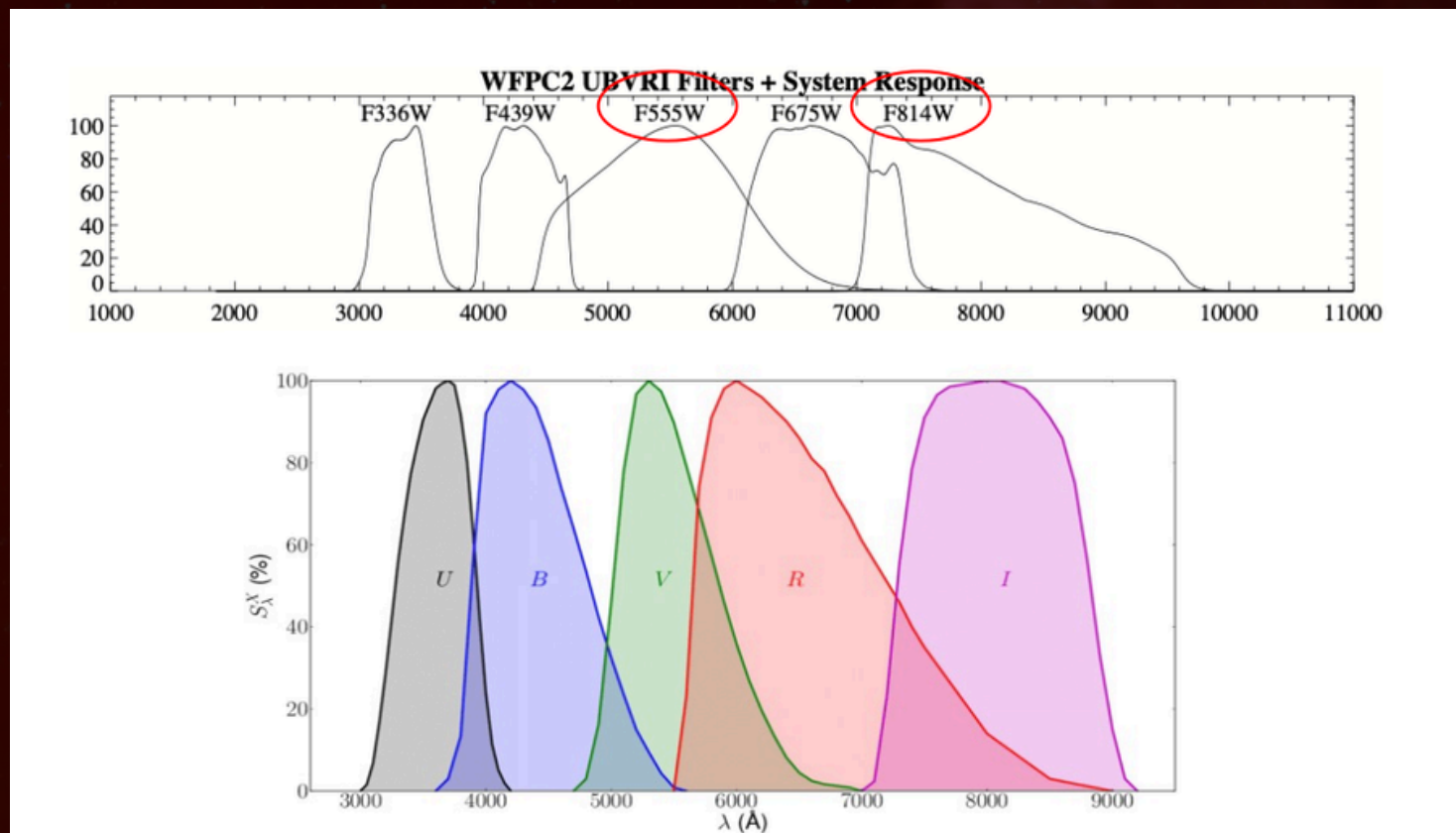
in order to track the variation in luminosity of the stars, we've repeated the process various times and with two different filters to get a more accurate average value of the apparent magnitude

by inputting the acquired data into the Periodogram software, we examined the most likely periods



this formula gives us the **average apparent magnitude** of a single star spectrum of the filter F555w, which roughly corresponds to the green filter normally utilized on telescopes on the Earth's surface.

the same process has been done for the filter F814w, which is almost alike to the infrared band



File Views Graphics Joins Windows VO Interop Help

Table List

- 1: Measurements.tbl
- 2: MeasurementsC3.tbl
- 3: MeasurementsC18.tbl
- 4: MeasurementsC19.tbl
- 5: MeasurementsC36.tbl
- 6: MeasurementsC38.tbl
- 7: MeasurementsC59.tbl
- 8: MeasurementsC65.tbl
- 9: stats of 1
- 10: stats of 2
- 11: stats of 3
- 12: stats of 4
- 13: stats of 5
- 14: stats of 6
- 15: stats of 7
- 16: stats of 8

TOPCAT(1): Table Browser

Window Rows Help

Table Browser for 1: Measurements.tbl

	J.D.-2400000	EXPTIME	Source-Sky	mag
1	50039.0274	1100	51.6575	25.86565
2	50046.39684	1100	39.4207	26.15917
3	50054.36628	1100	16.73503	27.08942
4	50057.18017	1100	27.22921	26.56089
5	50059.1899	1100	28.15068	26.52476
6	50065.1524	1100	55.93766	25.77922
7	50069.10517	1100	32.48952	26.36912
8	50073.05656	1100	24.75115	26.66449
9	50077.01073	1100	18.77029	26.9648
10	50084.06627	1100	20.22703	26.88365
11	50087.34683	1100	50.37721	25.8929
12	50062.14267	1100	67.23962	25.57942
13	49673.13457	1500	46.57637	26.31481

Total: 13 Visible: 13 Selected: 0

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232 / 1906 M

$$F_{555W} = -2.5 \cdot \log_{10} \left(\frac{C}{T_{\text{exp}}} \right) + ZP_{F_{555W}}$$

CONVERSION TO THE GREEN AND INFRARED BANDS

$$\begin{cases} V = F_{555W} - 0.052 \cdot (V - I) + 0.027 \cdot (V - I)^2 \\ I = F_{814W} - 0.063 \cdot (V - I) + 0.025 \cdot (V - I)^2 \end{cases}$$

distanza ngc3198.csv - LibreOffice Calc

File Edit View Insert Format Styles Sheet Data Tools Window Help

File Home Insert Layout Data

Paste Cut Clone Copy Clear B I U A² General

C7 fx 26.64096876177

	G	H	I
1	V-i	v	p
2	-0.291329228	26.1081268690855	25.66
3	-0.807479687	25.6824200977264	30.12
4	-0.063158451	26.0040637598979	25.02
5	0.306800056	26.4318947384615	18.76
6	-0.475985046	25.1951177413105	39.09
7	1.229172754	26.6178451513598	21.63
8	-0.148630544	26.2521348318207	18.33
9	-0.082242121	26.8116419912566	11.65
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Sheet 1 of 1

CALCULATING THE DISTANCE

Calculate the average absolute V magnitude by means of the
Period-Luminosity relation

01

$$M_V = \Sigma \cdot \log_{10}(P) + M_{V,0}$$

Calculate the distance modulus:

02

$$d = 10^{\frac{V - M_V + 5}{5}}$$

J	K
<u>Mva</u>	<u>distanza</u>
-4.95541864279431	16319584.689569
-5.13222939106733	14552241.6461235
-4.92755161208853	15357590.1875845
-4.60985750566675	16156617.7021761
-5.41983504577379	13273655.9736703
-4.76691722757166	18921365.535638
-4.58427427883091	14698798.0180243
-4.0842217185171	15106809.1261993

from the distances obtained by the
studies on each Cepheid, we got to the
actual distance of the galaxy, which
results to be:

$$d = (14.6 \pm 0.3) \text{ Mpc}$$

	A	B	C	D	E	F	G	H	I	J	K	L
1	mag_max555	mag_min555	media555	Magmax_814	Magmin_814	Media_814	V-i	v	p	Mva	distanza	
2	27.089415509333	25.579418565575	26.090686185814	26.645269871974	26.165307984473	26.378980537649	-0.291329228	26.108126869086	25.66	-4.9554186427943	16319584.689569	
3	26.441369309962	25.161470703657	25.62282652099	26.598673268445	26.271358560798	26.422727977963	-0.807479687	25.682420097726	30.12	-5.1322293910673	14552241.646124	
4	26.816162504224	25.540256672677	26.000671817718	26.494682099913	25.755167657075	26.063143503447	-0.063158451	26.004063759898	25.02	-4.9275516120885	15357590.187585	
5	27.155201312668	26.019686818053	26.445306931966	27.166613608174	25.624471733833	26.14206992884	0.306800056	26.431894738462	18.76	-4.6098575056668	16156617.702176	
6	26.0434024388	24.684908168259	25.16424935129	26.098405152104	25.311918102069	25.635451684943	-0.475985046	25.195117741311	39.09	-5.4198350457738	13273655.97367	
7	29.166108017842	25.942777628075	26.64096876177	25.628989348615	25.259048907571	25.428338639349	1.229172754	26.61784515136	21.63	-4.7669172275717	18921365.535638	
8	27.304099481654	25.717747892254	26.24380958549	26.645461901157	26.184748469059	26.390849375818	-0.148630544	26.252134831821	18.33	-4.5842742788309	14698798.018024	
9	27.922980998125	26.268639653805	26.80718277927	27.664246887874	26.440701199949	26.888533764269	-0.082242121	26.811641991257	11.65	-4.0842217185171	15106809.126199	
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THANK YOU