

## Main Sequence Fitting - NGC 2682 - Age and Distance Determination

Located in the constellation of Cancer, the open cluster NGC 2682 (aka M67) is one of the oldest clusters known. The stars in the cluster are scattered over an area of sky somewhat less than 30' (about the size of the full moon).

When the stars are plotted on a special H-R diagram called a colour magnitude diagram, it becomes apparent that they actually form a loose galactic cluster. The colour magnitude diagram is a plot of the visual magnitude  $V$  versus the  $B-V$  colour index. The  $B-V$  colour index is an indication of the temperature or spectral type of a star. Diagram 1 is a Colour-Magnitude Diagram for the familiar Nearby and Brightest stars. Comparison between Colour Magnitude diagrams for open cluster NGC 2682 and for the nearby stars allows one to determine the cluster's distance and to estimate its age.

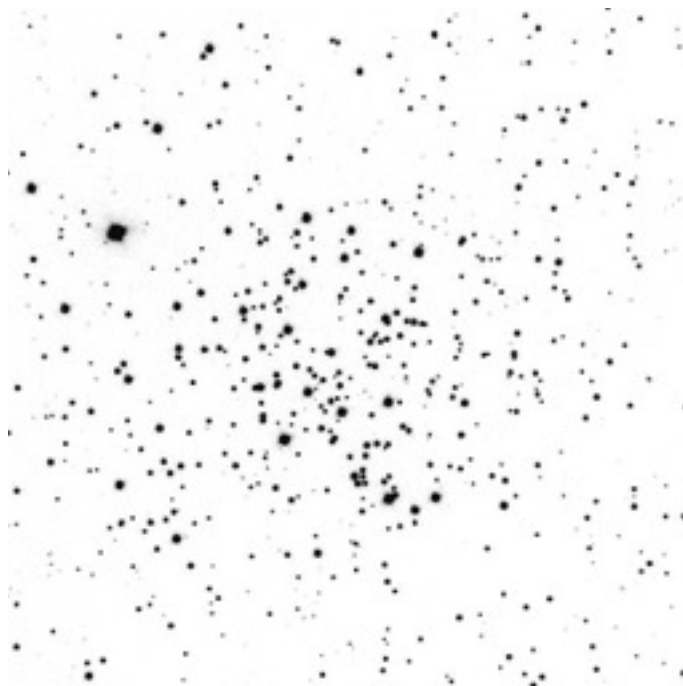


Table 1 lists the apparent visual magnitude, and the colour index ( $B-V$ , or blue magnitude minus red magnitude) for several stars believed to belong to the cluster.

Data were obtained from the following references:

New photoelectric observations of stars in the old galactic cluster M67  
 Eggen, O. J. & Sandage, A. R. *Astrophysical Journal* vol. 140, 1964 p. 130

Time-resolved CCD photometry of an ensemble of stars in the open cluster M67; Gilliland, Ronald L, et al. *Astronomical Journal*, vol. 101, Feb. 1991, p. 541-561

*Galactic Cluster NGC 2682/M67*

$B-V$	$V$	$B-V$	$V$	$B-V$	$V$	$B-V$	$V$	$B-V$	$V$
0.76	14.96	0.58	13.41	0.80	12.60	1.07	11.21	0.92	15.20
0.78	14.91	0.57	13.34	0.60	12.50	0.80	10.98	0.11	10.70
0.72	14.89	0.92	12.97	0.98	12.40	0.94	10.78	0.27	10.57
0.69	14.83	0.87	12.95	1.01	12.26	1.13	10.76	0.41	11.22
0.48	14.76	1.01	12.94	0.59	12.26	1.10	10.49	0.45	12.14
0.70	14.55	0.98	12.89	1.02	12.16	-0.07	10.03	1.38	9.72
0.67	14.46	0.77	12.81	1.05	11.68	0.11	10.99	1.35	9.69
0.64	14.05	0.81	12.79	1.05	11.50	0.80	16.19	1.15	17.10
0.61	13.95	0.69	12.70	1.08	11.32	1.00	16.64	0.56	12.74
0.61	13.60	0.51	12.67	0.63	11.31	0.78	15.87	0.86	11.52

**Table 1: Apparent visual magnitude ( $V$ ) and colour index ( $B-V$ ) of 50 stars in NGC 2682**

**Questions:**

1. Using table 1, plot the apparent visual magnitude  $V$  versus the colour index (B-V) on a piece of mm graph paper. The vertical scale should be 1 cm to 1.0 magnitude and the horizontal scale, 1 cm to 0.20 in (B-V). Label and title the diagram appropriately, indicating the scales used.

Label the following on your diagram: Main Sequence, Turnoff Point, Horizontal Branch, Asymptotic Giant Branch, Red Giant Branch, White Dwarfs

2a. Place the diagram of NGC 2682 over the nearby stars diagram supplied and line up the horizontal scales. Now determine how many magnitudes the NGC 2682 diagram must be shifted upwards so that the two main sequences coincide. This is  $(m-M)$ , the distance modulus for the cluster. Give an estimate of the uncertainty in the distance modulus.

b. From the distance modulus formula  $(m-M) = 5 \log R - 5$  determine the distance ( $R$ ) and its uncertainty in parsecs, to the cluster. Look up and record the distance quoted in the Observer's Handbook, in the list of Star Clusters. Are the values consistent? Comment.

3a. Explain how a cluster's age can be determined from its colour magnitude diagram.

b. The lifetime of a main sequence star can be approximated by  $t = 10^{10} (L / L_{sun})^{-3}$ . If the sun's absolute visual magnitude is +4.8 and its (B-V) color index is +0.65 what is the age of NGC 2682? In the RASC Observer's Handbook notice that only one other cluster has as late a turnoff point. What is this cluster and what is its turnoff point?

4a. Many of the stars in the direction of NGC 2682 are not actually members of the cluster, but stars in the line of sight, either closer or farther away. How can the cluster stars be distinguished from the field stars?

b. Look at the star located at 0.92 & 15.20. If it is not a member of the cluster, would it be closer or farther away? Explain.

5. The Coma cluster is only a few degrees away from the North Galactic Pole. Why, knowing this, would you expect the cluster to be relatively nearby? (A diagram of the Galaxy with the appropriate directions indicated would be useful.)

### Stars within 25 pc of the Sun

