Objectives

The primary purpose of this project is to introduce you to multicolor photometry of a large number of stars. The final result of the project will be a color-magnitude diagram with a few hundred stars. All the stars are in the double open Galactic cluster NGC 869/884 (J2000 coordinates RA = 02h 20m and Dec = +57° 08'). It will be possible to obtain a rough estimate of both the distance to and age of the cluster by main sequence fitting. Note: This double cluster is nearly in the plane of the Galaxy and suffers significant extinction and you will have to use estimates of the interstellar reddening to correct your data.

Observation Preparation

Print a finding chart of NGC 869/884 from the digitized Palomar Sky Survey available on the web. Determine when NGC 869/884 will be at an acceptable air mass and pick appropriately located calibration stars. To determine air mass as a function of time, you may use one of the Observer’s Helper’s linked to the class website. Then pick four calibration stars with a range of (B-V) colors from the UBVRI Standard Stars in the Astronomical Almanac. Make finding charts for all the calibration stars so that you will be able to identify them on the CCD frames. Determine their air masses for various times during the evening. This is to make sure that they will be "up" when you need them.

Observations

Although you should be able to complete all the observations necessary for this project in a single night, be prepared to stay very late. These clusters are at high declination and will be visible all night long. Accurate photometry requires good sky conditions so don't proceed with your observations unless the sky is clear with no cloud cover in the forecast. Also, make sure you know where the moon is before you start.

The field of view of the SBIG CCD is about 12 arcmin by 8 arcmin. You need to obtain two adjacent (north-south) frames of NGC 869/884 to observe roughly a 12 × 16 arcmin composite field. This is large enough to include many of the stars in the double cluster. Take two or three exposures of each of the two pointings in each of the BVRI filters. You will have to experiment to find the proper integration times. It may be necessary to take both short and long exposures in order to be able to photometer all the stars in a given field. This is because the bright stars might saturate during the long exposures, and it is these bright stars that will be crucial in determining the main sequence cutoff.

Take three images of each of your calibration stars in each of the BVRI filters. It would be a good idea to do this twice, once before and once after you take your cluster frames. Be sure to record the time and altitude of each observation. Make sure that one of the calibration stars is
observed at several different air masses (at least 3) in order to allow you to determine atmospheric extinction. You may also be required to make "color corrections" since the "calibration constants" may depend on the (B-V) color of the calibration stars. That is why it is important to pick calibration stars with a range of colors. You will also need to experiment to find the proper integration times for each of the calibration stars in each filter.

You need to take the usual number of dome and twilight flats.

**Data Processing**

Transfer the FITS files of your data to your directory on HAL. Once you have reduced your images, use aperture photometry to determine the instrumental magnitudes of the calibration stars in each exposure. A plot of instrumental magnitudes versus air mass will allow you to determine atmospheric extinction in each photometric band. After correcting for atmospheric extinction, determine the calibration constants for each calibration star in each band. Plot the calibration constants versus (B-V) to determine color corrections.

Then locate and photometer all the objects in the cluster frames. It will be useful to align all frames taken at a given cluster position and to combine those taken with the same filter. We will try different methods of image combination in class.

The IDL procedures *find* and *aper* will be workhorses for these calculations. ATV can also be used to do aperture photometry of the individual calibration stars.

**Analysis**

Make a table with the magnitudes and colors of all cluster stars. Be sure to include measurement errors. Make several color-magnitude and color-color plots. After correcting for interstellar extinction, estimate the distance to the cluster by comparing with the color-magnitude diagram of a cluster at a known distance. Make a rough estimate of the age of the cluster from the absolute magnitude and/or color of the position of the turnoff.

**Formal Report**

Your formal report should include: (1) an ABSTRACT in which you briefly summarize the results of the project; (2) a brief INTRODUCTION (1/2) page; (3) a description of the OBSERVATIONS that includes the date, sky conditions, telescope, camera, object plus coordinates, method of calibration, etc.; (4) a description of the ANALYSIS that includes tables and figures of the results; (5) CONCLUSIONS in which you again summarize the results (include distance and age estimates here); and (6) a REFERENCE section. You may consult with your collaborators on the results you present but reports should be written separately.