

# Tutorial: Quick Look Photometry with IRAF

Kaustubh Vaghmare

In this tutorial, we will learn the technique of doing quick-look photometry using IRAF. This will be (surprisingly!) done using the 'imexamine' task. In fact, you have already done quick look photometry! When you used the imexamine task and used the 'r' command you were doing photometry whether you knew it or not. And if that leaves you puzzled, it means you have not looked the help section of the imexamine task. Anyway, let us first cover some simple basics of photometry very quickly.

## 1 Photometry Basics

Photometry refers to the measurement of the total flux being received from the object. However, the measurement of the exact flux is highly complicated as a process. Even more difficult is the process of quantifying the level of uncertainty in your final measurement. This is beyond the scope of the tutorial, our job here is to tell you how very easily, you can do quick look photometry using IRAF's imexamine task. But first things first, let us revise the concepts of photometry.

Brightness of an object i.e. the amount of flux received from the source is measured in a system known as *magnitudes*. The reasons for using this are partly historical and the reader is encouraged to refer the excellent book called *Astronomical Photometry* by *Henden & Kaitchuck*. The system is defined as follows - if the ratio of flux from two stars is 100, then the difference in their magnitudes is 5. This, for the mathematically oriented, should quickly tell you that the magnitude scale is a logarithmic scale.

$$\frac{m_1}{m_2} = -2.5 \log \left( \frac{f_1}{f_2} \right) \quad (1)$$

But if you have seen any table stating the brightnesses of these objects, you will see values like -3.0 and 1.5 etc. But the above equation tells you about the measure of difference in magnitudes. So, how does one assign a single unique value to an object? There are many schemes to do this but the most common one is called the Vega system. In this system, the magnitude of the star Vega is assigned 0. Then, to assign a brightness to any object, its flux is compared with that of Vega and the above equation can be used to assign its magnitude.

**NOTE:** Carefully study the above equation. The  $-$  sign tells you that the magnitude scale has an inverse sense. A magnitude 5 star is fainter than a magnitude 1 star. This is very unintuitive at first but with time, you will praise the fact that this is inverse. (Thought Exercise: Think about advantages of having an inverse system like this.)

Next comes the question of flux measurement. Take a look at any image of say, a star and we know that it occupies a finite space. We just mark a suitable region, sum up all the fluxes in each pixel and done - we have a flux measurement. Unfortunately, this flux measurement is not going to be correct. This is because it includes contributions from several other sources - the moon in the sky, distant but unseen galaxies or stars, sky emission etc. This needs to be subtracted.

This means that we need a method by which we can get the per pixel contribution from such sources and subtract them from our measured flux. To do this, we will choose an annular region sufficiently away from the source of interest, unoccupied by any other source, measure the average value of the pixels and subtract it from what we consider to be a source measurement. This process is called aperture photometry and is illustrated in Figure 1. The pink region is used to get sky contribution. The red region is assumed to contain flux from the source.

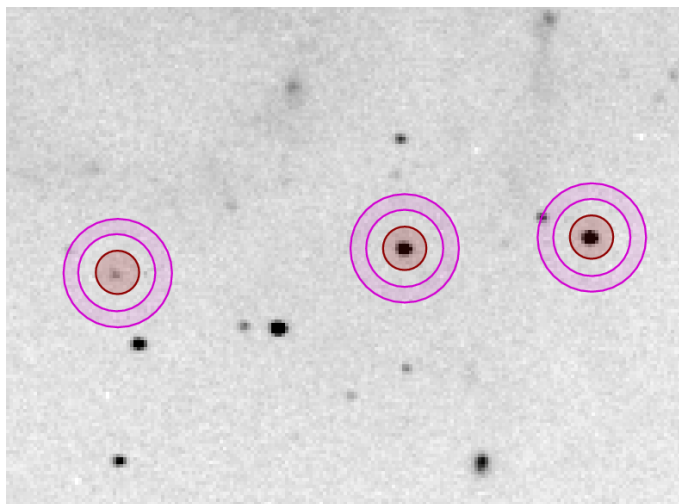


Figure 1: Illustration of how aperture photometry works. The pink region is used for estimating the background contribution and the red region is for measuring the flux of the object.

The 'imexamine' task can do a quick photometry of the object of interest. So, let's get started.

## 2 Quick Look Photometry with imexamine

1. Start IRAF! (You should know this by now!)
2. Go to the folder where you did your image reduction process. If you haven't done so, then use an unprocessed image for practice.

```

voc1> cd IRAF_Demo_Data/
voc1> display m67_b_final.fits
frame to be written into (1:16) (1):
z1=15.62531 z2=32.84292
voc1>

```

3. And then, start imexamine by simply typing imexamine. We've seen how to do this. Go ahead. Give the stars in the field some name of your choice, say A B C D E F etc. Now, point cursor to each star, press 'r' to get its radial profile. For each radial profile plot, there is a yellow strip at the bottom of the plot which contains some numbers. Note them down.
4. By now, you should be an adept user of IRAF. Use the help section on IRAF and understand what each of these quantities are. Then prepare a table which contains columns - name of the star as chosen by you, its centre and all other quantities with appropriate names (as found by you from the help section).
5. Now, prepare another table which has following columns - name of the star, its magnitude. To measure the magnitude, you must choose some value of your choice for any one star and give magnitudes of other stars as per your choice. Below is an example table (don't take values seriously, measure them yourself). Clearly indicate which star was assigned what magnitude by you. In below mock example, I am assigning 0.0 to A.

Star's Name	Magnitude
A	0.0
B	1.2
...	...

6. So, imexamine's 'r' command does aperture photometry. I hope you have read the help section and understood how it does what it does. We know there are parameters being used by

imexamine to decide the size of the aperture. Can we control them? Yes, of course.

```
vocl> epar rimexam
```

This will bring the parameters controlling the behavior of 'r' command. The parameters of our interest are - object radius, buffer and background width. Now, choose any one star of your choose, a considerably isolated one. Keep repeating imexam operations on the same star, each time changing the value of object radius. Take measures for 7-8 different object radii for the same constant (and large) background. Make a table. Try to make a plot of flux as a function of object radius. Comment on the plot.

I hope that with the tedious tasks given to you in this tutorial you get a more intuitive understanding of aperture photometry and challenges involved in it. I conclude by urging you to read at your own leisure the book *Astronomical Photometry* by *Henden & Kaitchuck*.

**Think!**

- What is the limitation of aperture photometry? When can it be applied, when can it not be?
- What is the best object radius for accurate flux measurement? Can we always measure with such a radius? If not, what can we do?
- If I simply measure the object flux for 'A', then point my telescope to Vega, measure its flux, can I simply use the magnitude equation to determine magnitude of the star? If not, why?
- In the kind of background estimation and subtraction used in above technique, what is the most important assumption being made? Is it always true? If yes, why? If no, why not?
- Did 'r' command give you a very accurate centre for your object? Is it in fraction of pixels? How can it possibly find such a centre?
- Why should a Gaussian shape describe the radial profile of your star so well?
- If bias had not been subtracted, it would appear as a simple additional background, right? And since we are modelling it, we can as well measure flux without doing bias subtraction. So, why do we need to subtract bias to begin with?