"Quantized Beyer's Method", Ferrín (1992).
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QUANTIZED BEYER'S METHOD (QBM), TO ESTIMATE ACCURATELY THE BRIGHTNESS OF EXTENDED OBJECTS AND STARS

IGNACIO FERRIN
Grupo de Astrofisica, Departamento de Fisica, Universidad de los Andes, Merida, 5101 Venezuela, and LIADA, Ibero-American Astronomical League, Apartado 700, Merida 5101-A, Venezuela

INTRODUCTION

The most used methods to estimate visually the brightness of a comet, are those of Sidwick, Bobrovnikoff, Morris and Beyer (Edberg and Ferrin, 1986). They are explained and compared in Figure 1. The main point of this graph, is that Beyer's Method should be the most accurate to evaluate the brightness of comets and extended objects, because by defocusing the telescope completelly, the images of object and comparison stars are more simmilar or alike than in other methods. And it turns out that the defocusing can be measured with better than 0.1 mm. For 50 years since 1926, Max Beyer conducted observations of the brightness of comets that are now of historical value, and which support this conclusion. Beyer died in 1989, and his work still has not been adopted as standard and recognized for the value it has. Bouska (1970) has called attention to the lack of homogeneity of current observations of comets. Figure 2a shows measurements of comet Ikeya-Seki 1968 I, by several observers, and Figure 2b measurements by Beyer and Wenske. Note the large dispersion of the points, and the existence of a "deep" around March 25th. Note also how Figure 2b represents a real improvement, and how the deep has disappeared. Bouska concludes that "some outbursts of comets could be explained as observational errors". The situation has not changed since then, since methods and equipment are still the same.

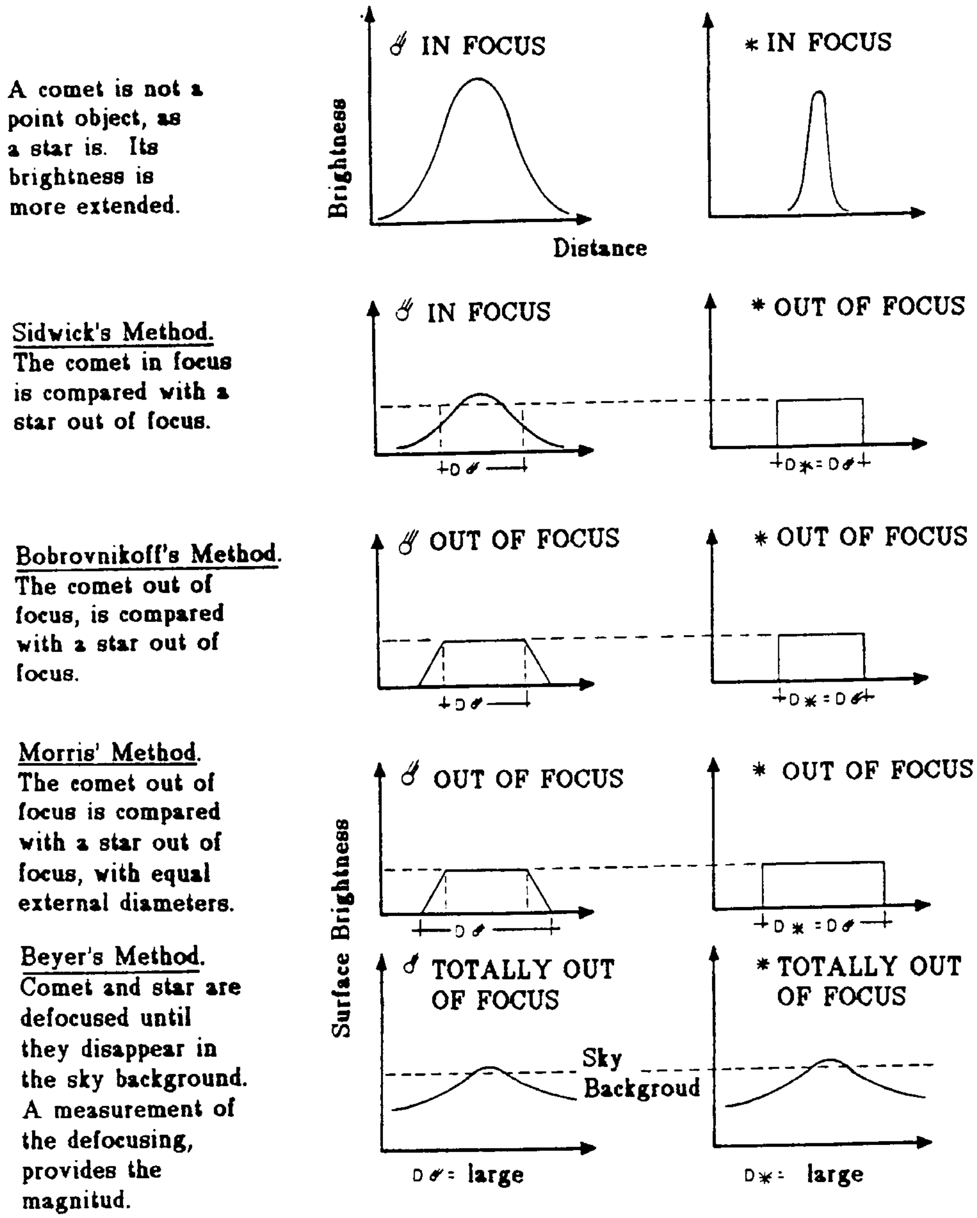

Figure 1. Visual methods of comparison for extended objects.

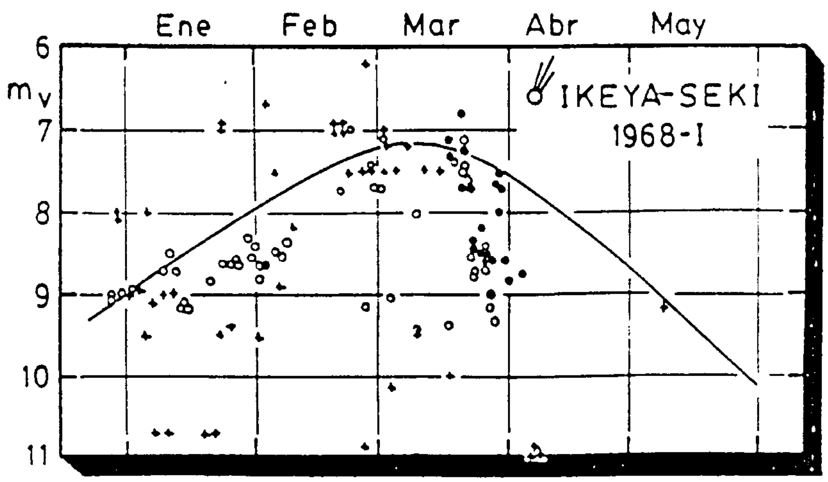

Figure 2a. Brightness of Comet 1968 I vs time. Photographic observations (+), visual estimates (o) and ALPO magnitudes reduced to 6.8 cm apperture (full o) are shown. Note the large dispersion of the points, and the minimum between 20 and 30 of March.

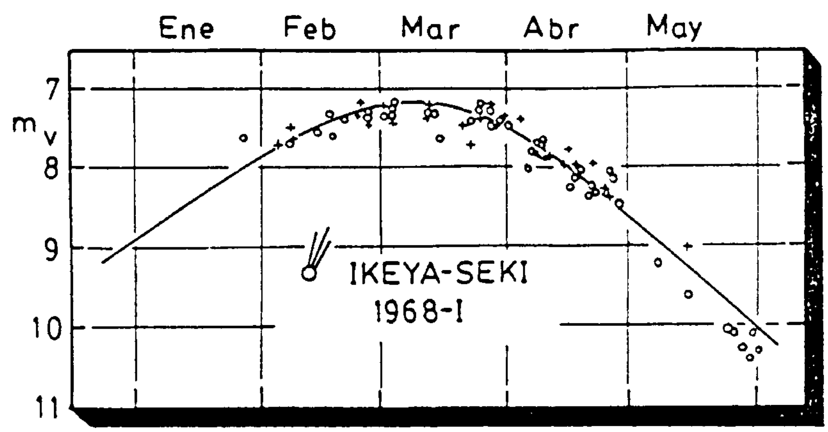

Figure 2b. Visual observations of the same comet by Beyer (o) and Wenske (+). Note the small dispersion of the points, and the fact that the minimum has disappeared. The mean error of these measurements is only 0.20 magnitudes.

Beyer used a method to estimate the brightness that consisted of comparing the extrafocal points at which the defocused image of comet and comparison stars, were indistinguisible from the sky background. But he never published detailedinformation on how this comparison was to be performed. At least we did not find any, in a literature search conducted with a friend who speaks fluent German.

In fact, nowhere in his works, does he mention the word "calibration plot", which is central to our work. Thus we believe that we have improved over his method. The QBM (Quantized Beyer's Method) is capable of reducing the error to only 0.05-0.20 mag, and it is so called because it meakes use of an accurate calibration to estimate the brightness.

QBM

The idea of the Method is to measure at what point a star disappears in the sky background, with increasing defocusing. In 1983 I decided to calibrate the defocusing using a scale on the focusing tube of the telescope. The scale can be in any units, so long as it is regular (Figure 3). I used milimeters. Next, I measured a set of comparison stars. The Pleiades were very useful for this purpose (Roth, 1974; Figure 4).

Surprisingly a plot of magnitude versus logarithm of the defocusing was a perfect straight line! In Figure 5 I show my plot of the Pleiades (Ferrin, 1983), made with a refractor of 2.4 inches, with 36x. In my first try, my error was only 0.19 magnitudes, a very small value! And the relationship was linear for more than 5 magnitudes, or a factor of 100! A linear relationship is what you want to make reliable measurements! In case this were not enough, notice that the systematic error is zero! This means that you are exactly on the international UBV system, except that your random error is slightly larger!

After my first report, four observers in 3 countries were able to confirm my results obtaining even lower random errors: Villar and Paolantonio in Argentina, Torres Lapasio in Spain, and Chacon in Venezuela. All of us worked with real objects in the sky.

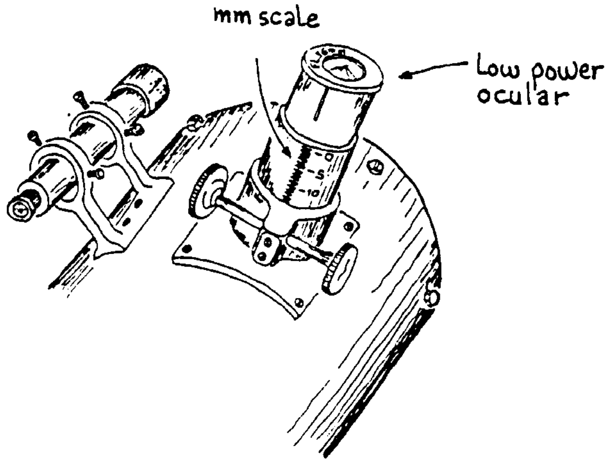

Figura 3

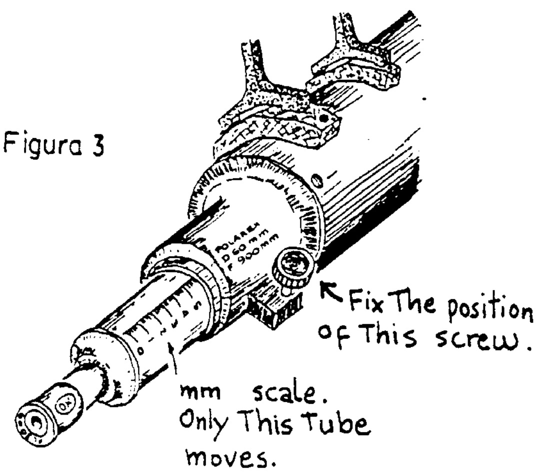

Figure 3. Some kind of regular marks have to be made on the focusing tube. A scale in millimeters is best. Use an ocular of low power.

ADVANTAGES

QBM has several advantages over other methods:

1) In all other methods you have to remember something or carry over something (brightness of star or comet). In QBM you have to remember nothing, and carry over nothing. Thus QBM should be more accurate than other methods. And it is.

2) The more calibration stars you measure, the better the calibration line. If you have a computer, it is better to get the least square best fit.

3) The comparison stars do not need to be near the object, so long as the background sky is the same.

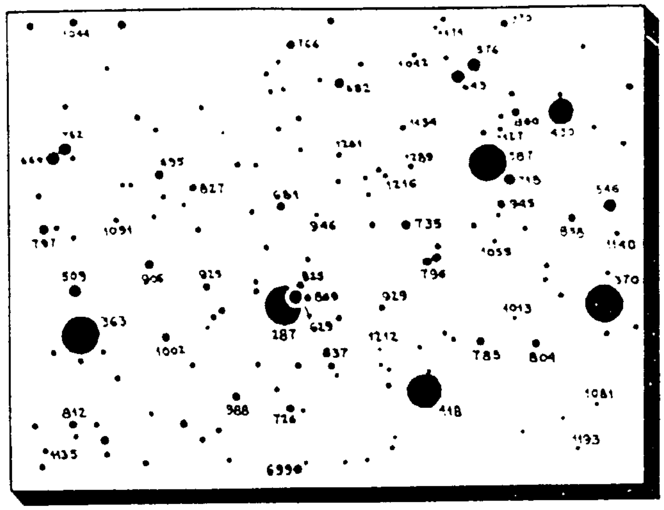

Figure 4. The Pleiades have calibration magnitudes that can be used to calibrate your instrument (Roth, 1974).

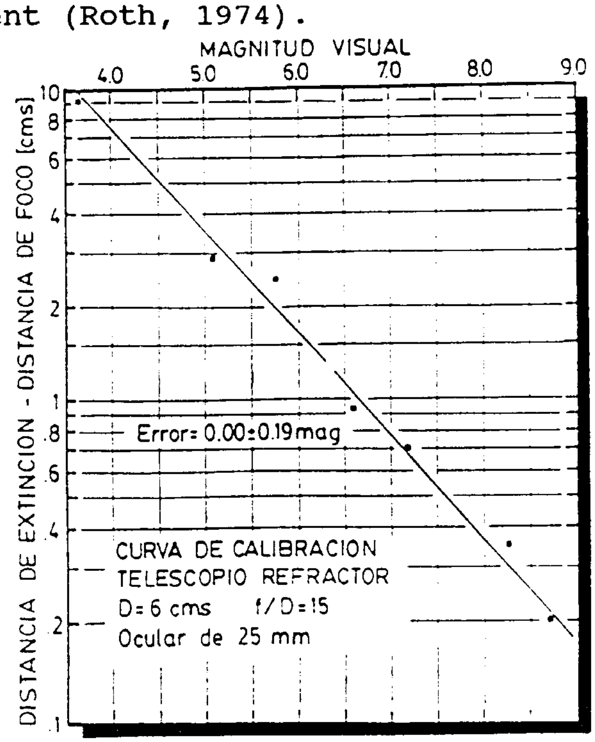

Figure 5. Calibration curve of a small refractor. The distance of extinction minus the distance of focus is plotted vs. the visual magnitude. Note the vertical axis is logarithmic. The systematic error is zero, and the random error is only 0.19 magnitudes. From night to night, the slope is the same but the vertical position may vary.

In fact they can be quite apart. This is an important advantage, if there are no comparison stars nearby.

4) The slope of the line does not change with night. Only the vertical position does depending on the sky background. The method allows the quantitative study of your background sky!

5) Once you have your calibration curve YOU DO NOT NEED FAINT COMPARISON STARS TO MAKE A MEASUREMENT. YOU CAN MEASURE FAINT OBJECTS, USING ONLY BRIGHT CALIBRATION OBJECTS! (Because you know the slope). Thus after calibration just 2 stars are enough to make a measurement. They do not even have to bracket the object. If the two stars show a different slope than the calibration line one of them is variable o has the wrong magnitude. Then you have to use a third star. This is a very important advantage, because in the case of comets, it is not allways possible to find proper comparison stars to bracket the comet. The same thing happens for faint variable stars, or for unexplored fields.

6) Bad comparison stars are easily detected (they depart from the calibration line) and rejected. In fact in this way a new small range variable star has been discovered (Chacon, 1988).

7) By using a calibration curve, you avoid systhematic error (you actually set if equal to zero), as well as reduce random errors. A criticism has been that it is time consuming making this calibration. It is not.You will expend less than an hour. And the calibration will last you as long as the ocular and telescope.

8) QBM is susceptible of improvement. It can be used to measure not only diffuse objects, but variable stars, minor planets, planetary satellites, etc. It would be interesting to study the Purkinje effect using QBM. QBM would permit the calibration of fields around galaxies, useful in the search for supernovas. What is the influence of the Moon light on cometary measurements? What is the lowest possible random error achievable with QBM?

What other method gives you so much for so little?

CARE WITH THE QBM

It is important to take care of the following points:

A) If the outfocused disk of two nearby stars get superimposed, they can not be used as comparison. Use a higher magnification ocular, which needs less defocusing, but a new calibration (different slope).

B) Since QBM works at the sky limit, it is important to be dark adapted. If you make one estimate dark adapted, and another not dark adapted, they are going to differ.

C) Because of the same reason, do not use a white light flashlight. Use a red one.

D) Try to have the comparison stars as near to the object as possible. A few degrees is still OK. Avoid gradients of light.

E) To improve the numerical values take the mean of the outgoing (extinguishing) and ingoing (reappearing) measurements. Repeat several times until you get aquainted.

G) To detect if the images of the star or object are still there, move the telescope slightly and use "averted vision".

H) Because the method requires of defocusing, it may not work with binoculars and reflectors. A refractor is best.

RESULTS

Actual measurements on the sky, with real extended objects, confirm these results fully.

Ferrin and Naranjo (1980) were able to fit Beyer's measurements of Comet Encke with a theoretical law, with a small error of only 0.15 magnitudes.

Figure 6 shows a comparison of photoelectric measurements and those of Beyer for several extended objects (not comets). The mean error is only 0.17 magnitudes.

Figure 7 presents the calibration made by Torres (1991) which shows a 0.03 magnitude error.

From these Figures, and from Table I, we conclude that the error of the QBM Method is very small, much smaller than in all previous methods of comparison used for comets or variable stars, and reaches typically 0.17 to 0.07 magnitudes, decreasing with experience.

For comparison Figure 8 shows the measurements made by Bortle (Houston, 1976), of extended objects, using Bobrovnikoff's Method. His mean error is 0.32 magnitudes, much larger.

DELTA EFFECT

Theoretically if a very diffuse comet approaches the

TABLE I Errors of Different Methods

Bobrovnikoff's Method	
AUTHOR	ERROR
Bortle (1983)	0.32 mag

Beyer's Method	
AUTHOR	*ERROR*
Ferrin and Naranjo (1983)	0.15 mag
Ferrin (1983) Pleiades	0.19
Beyer's extended objects	0.17
Villar (1991)	0.08
Torres Lapasio (1991)	0.03-0.08
Chacon (1988)	0.07
Paolantonio (1988)	0.17
	Mean = 0.12 mag

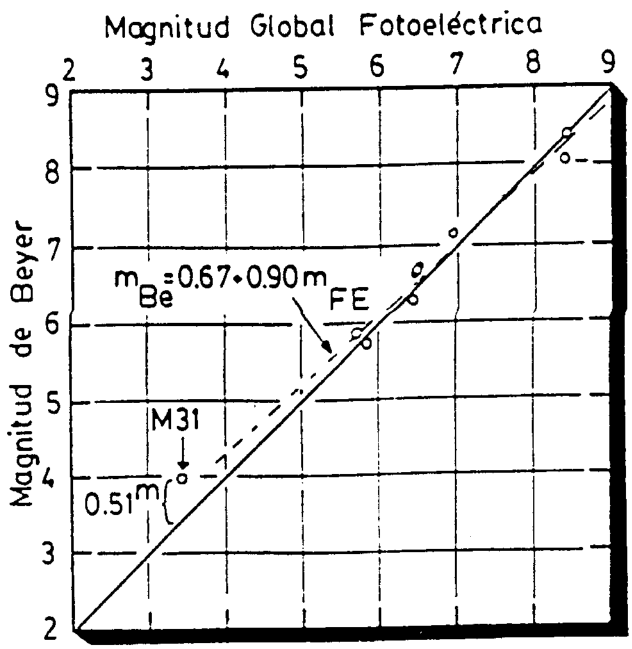

Figure 6. Comparison of Beyer's measurements of extended objects vs their real photoelectric magnitude. The line at 45 degrees would indicate perfect agreement. The mean error of these measurements is only 0.17 magnitudes. M31 departs from the line due to the "Delta Effect" (see text).

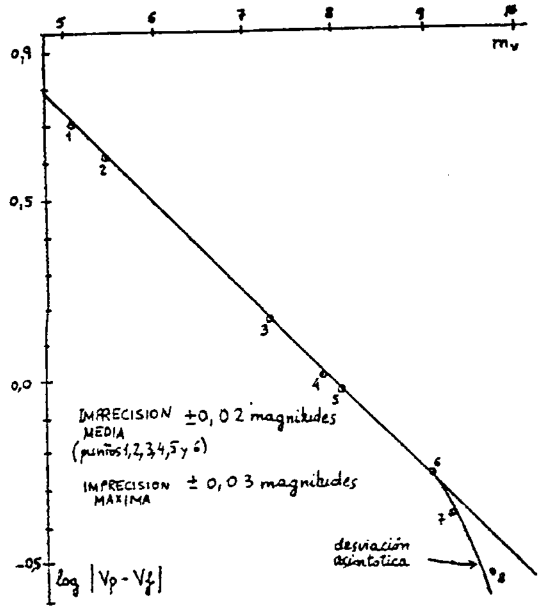

Figure 7. This calibration curve made by Torres Lapasio (1991) give even a smaller error of only 0.03 magnitudes! Notice that the linear portion of this plot extends more than 4.5 magnitudes, a very desirable feature. Notice also that near the focusing point the line departs from linearity.

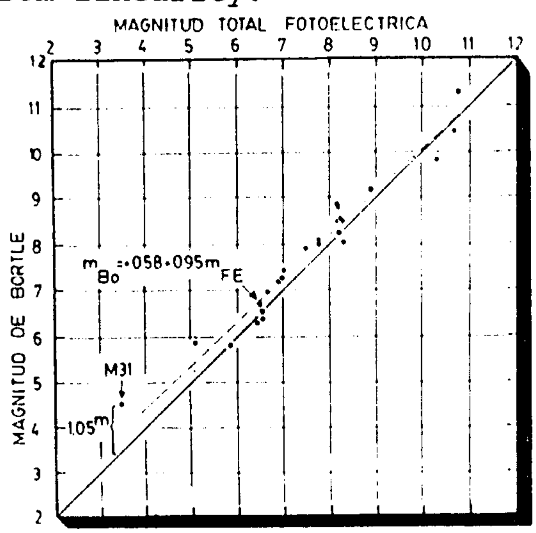

Figure 8. Comparison of the magnitude of extended objects measured by Bortle (Houston 1976), using Bobrovnikoff's method, and their real photoelectric magnitude. The mean error of this data is 0.32 magnitudes. M31 also departs from the 45 degree line, but by twice the amount than in QBM method.

Earth, the outer regions of the comet should be washed out, and the object should lose some magnitude. This is what has been called the "Delta Effect". Figures 6 and 8 show precisely this.

Messier 31 (Andromeda's galaxy) loses 0.51 magnitudes using QBM Method, and 1.05 magnitudes in the Bobrovnikoff Method.

This is again independent evidence of the superiority of QBM, and proves that the so called "Delta Effect" does indeed exist.

CONCLUSIONS

For decades it has been known that Beyer's estimates of cometary brightness are rather accurate. We fully confirm this result, and extend the validity of the method. It is surprising however to read in the NASA Report on Comet Crommelin (page I-30), that any other method than those of Bobrovnikoff, Sidwick or Morris was reason for not including the observation in the archive. This policy should be discontinued.

In conclusion, we recomend the QBM as a method that should be adopted by observers of variable stars and comets alike, because it is simple to use, very accurate and fast, and susceptible of improvement.

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