Systematic Search for Gravitational Mirages among General Quasar Samples*

O. Moreau [1†], J.-F. Claeskens [1],
E. Gosset [1], H. Reboul [2] and J. Surdej [1‡]

[1]Institut d'Astrophysique, Université de Liège,
Avenue de Cointe 5, B–4000 Liège, Belgium
[2]Laboratoire d'Astronomie, Université de Montpellier 2,
F–34095 Montpellier Cedex, France

Abstract: We present the status of a systematic photographic search for gravitational mirage candidates among general quasar samples, i.e. samples not restricted to highly luminous objects. We also show how the results of such an observing program may constrain the number–magnitude relation for quasars.

1 Introduction

During these last years, searches for gravitational mirages have mainly been conducted among highly luminous quasar samples, these objects being more likely to be affected by gravitational lensing effects [SUR93.1]. Indeed, given that the number–magnitude relation for quasars is believed to flatten out around B=19.15, the magnification bias only ought to be important for bright quasars. However, if there was no such a flattening, as suggested by Hawkins and Véron [HAW93.1], the situation could be quite different. In October 1991, we proposed to carry out at ESO a complementary search for gravitational mirages consisting in the systematic photographic imaging of known quasars taken from quite general samples, without applying any absolute luminosity criterion. This is a natural extension towards the study of the morphology of objects with lower apparent magnitudes, typically with apparent visual magnitudes in the range 18 – 21. Referring to the debate about the number–magnitude relation, it is of course very interesting to investigate how these fainter QSO samples are affected by the magnification bias.

*Based on photographic plates obtained with the ESO Schmidt telescope (La Silla, Chile) and on digitizations made with the MAMA measuring machine of C.A.I. (I.N.S.U., Paris)

†European Space Agency fellow

‡Maître de recherches au Fonds National de la Recherche Scientifique (Belgium)

2 Field selection and plate request

Observing time with the ESO Schmidt telescope (La Silla, Chile) has been awarded to this program: we have selected four fields (see table 1) containing a high density of known quasars from the Véron–Véron catalogue (1991); we requested 2 plates per field, in the J (IIIaJ without any filter) and R (IIIaF+RG630) bands, to be taken under good seeing conditions (about 1 arcsec or less) and with a very careful guiding. Indeed, for an investigation of the morphology of objects as this one, it is important to minimize the spread of photographic images and also to dispose of more than one plate per field in order to prevent from spurious — due to noise — candidate selection. The plates cover 5.4°×5.4° zones, i.e. about 30-square-degree fields, down to a limiting magnitude corresponding to about V=22 for the studied quasars (60 min exposures).

Field name	Alpha $_{1950}$	Delta $_{1950}$	Number of known quasars
UK1	0h 53min 00s	-28° 03' 00"	347
UK352	1h 11min 50s	-35° 11' 20"	183
UK2	2h 00min 00s	-50° 00' 00"	87
PBF23	2h 52min 52s	+00° 23' 10"	120

Table 1: Selected fields

3 About the number–magnitude relation for quasars

If the flattening of the number–magnitude relation reported near B=19.15 is caused by observational biases (cf. [HAW93.1]), the fraction of lensed quasars with visual apparent magnitudes in the range 18 – 21 should also be relatively high. In order to estimate the influence of such a flattening, we have computed the number of gravitational mirages due to galaxy deflectors expected to be discovered among the population of 709 objects (corresponding to all the quasars from the four selected fields for which a V magnitude and a redshift are given), with a limiting magnitude V=22 and a seeing of 1 arcsec. This statistical estimate (see table 2) is based on the modelization of the lensing galaxy by a singular isothermal sphere (Claeskens, 1992) [SUR93.1], using an effectiveness parameter F=0.047 from Fukugita and Turner [FUK91.1]. Optical depths for lensing are computed in a Friedmann universe (with Λ=0) for two different values of Ω_o, the value of H_o being irrelevant. It is to be noted that this estimate does not take into account any deflection due to galaxy clusters and thus only deals with the discovery of mirages with angular separations between the lensed images of 3 arcsec or less.

Ω_o	Flattening at B=19.15	Flattening at B=21	Flattening at B=30
0.1	1.3	5.2	30
1	0.75	3.0	23

Table 2: Number of expected mirages with separations $\leq$ 3" in the sample

One can see that, besides the proper interest of the possible discovery of new cases of gravi-

tational lenses, the number of mirages that should be found in the four quoted fields may be quite instructive about the number–magnitude relation for quasars.

4 Selection of potential mirage candidates in field UK352

At the present time, only the UK352 field plates have been obtained; these plates have been digitized using the MAMA microdensitometer.

4.1 Digitization with the MAMA measuring machine

MAMA is a fast multichannel microdensitometer developed by INSU (*Institut National des Sciences de l'Univers*) for C.A.I. (*Centre d'Analyse des Images*) and located at Observatoire de Paris, France (for details, see Guibert and Moreau, 1991). This accurate measuring machine was used in its *pavés* mode (Berger et al., 1991) in order to extract small 3'×3' images around each known quasar on the photographic plates. A pixel size of 0.67 arcsec (corresponding to 10μm on the digitized plate) was used with a 4096-level quantification of the density.

4.2 Extraction of potential candidates

A careful visual inspection has been conducted on the digitized images. We searched for a possible non–stellar aspect of the objects, an elongation or a multiplicity of their images. Thus, a first list of 12 potential gravitational mirage candidates has been extracted out of the 183 known quasars in the field, including 3 candidates with image separations smaller than 3 arcsec and thus relevant for a comparison with our estimates in section 3. These objects are to be observed spectroscopically at ESO–La Silla with the NTT 3.5m telescope.

5 Conclusion

Numerical simulations show that the number of gravitational mirages that could be discovered among general quasar samples is expected to significantly constrain the number–magnitude relation for quasars, provided the number of quasars is of the order of several hundreds. This program is to be continued by analysing the three remaining fields and the observation of the selected potential candidates.

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