CATALOG OF SUPERMASSIVE BLACK HOLES FOR 
INTERFEROMETRIC OBSERVATIONS

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The paper presents a catalog of supermassive black holes (SMBH) shaped for the interferometric observations in millimeter and submillimeter wavelength ranges and based on the open sources. The catalog includes the name of the object, coordinates, angular distance, the mass, the angular size of the gravitational radius of SMBH, the integral flux of radiosource, related with SMBH, in the range 20 ÷ 900 GHz which is considered to be used in Event Horizon Telescope, future space mission Millimetron and others.

The catalog is intended for use during the planning of the interferometric observations of SMBH shadows.

I. INTRODUCTION

Black holes are the most interesting physical objects in the Universe. The possibility of the existence of bodies whose gravitational field is so strong that even the light cannot escape their gravitational “pit” was first considered by J. Mitchell in 1783. In 1796 the similar reasoning was expressed by P.-S. Laplace. However, until the creation of the relativistic theory of gravity, the idea of the existence of “dark stars” remained purely speculative. After the appearance of the General Theory of Relativity (GR) the situation has changed. The exact solution of the Einstein equations for a point-like mass was first obtained by K. Schwarzschild at the turn of 1915 and 1916. In the spring of 1916 the same solution was presented in the thesis of O. Droste (whose scientific supervisor was H.A. Lorenz) in the form, which later became standard. Soon after that in 1918 H. Reissner and G. Nordström
found the solution of the Einstein equations for a massive body with an electric charge. Many years later, the solutions of the General Relativity equations for a massive rotating body (Kerr metric) and a rotating charged body (Kerr-Newman metric) were also found.

Along with the search of the exact solution of General Relativity equations the physicists tried to comprehend what are the properties of a body described by the Schwarzschild metric (Kerr metric, etc.) or simply answer the question: what this object is? Following the successful joke of the famous witty J.A. Wheeler this body in 1968 was assigned a name of a “black hole”1. For the objects described by the Schwarzschild and Kerr metrics, the corresponding names were fixed: Schwarzschild black hole, Kerr black hole, and so on. A lot of interesting facts on the history of black holes can be found in the popular science book ([1]), two essays [2] and [3], and in the review [4].

In 1935 A. Einstein and N. Rosen considered a structure that was the union of two black holes “sewed together” exactly at the gravitational radius (Einstein–Rosen bridge). The purpose of the creation of this construction was to avoid the problem of singularity, i.e. the appearance of the configurations with infinite curvature. Later, the family of black holes acquired the “relatives”: white holes ([5]), wormholes ([6]) and black-and-white holes (see [7], [8]).

The aim of this paper is not to investigate what is hidden beneath the horizon of black holes, but to present for interferometric observations a compiled catalog of known black holes located in the central regions of galaxies. The reason to accent the attention on supermassive black holes (with a mass $M \geq 10^4 M_\odot$) is that they are the most convenient objects for observations because their angular size is greater than the one for the stellar mass black holes.

It seems there are four ways to create a black hole. In the first case black hole may be born at a final stage of a massive star evolution. Such a star can belong to any generation of stars. Also, black hole can appear as a result of gas instability that result is direct collapse. The third way is related with star-dynamical processes in star clusters. More details concerning these three ways can found in [9]. Finally, black hole may appear in result of collapse of an overdensity region. In this case we deal with primordial black hole (PBH).

It is widely known that the black hole emits nothing to surrounding space except the

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1 It seems the author of this name is Ann Ising who first used it as early as in 1964; see [1], p. 152.
Hawking radiation, that has the quantum nature. So, it is desirable to make clear the sense of the expression “the black hole observations”. Throughout the decades, this meant the radiation of matter in the gravitational field of a black hole. More specifically, this meant the radiation generated inside or near the jet and/or accretion disk. At present time the “black hole observation” includes also the investigation of a black hole shadow or silhouette.

The form of a black hole shadow is determined by several parameters. Two of them refer to a black hole. In the frameworks of GR they are the mass of a black hole and its momentum. The others describe the source of the photons emission. If it is the accretion disk the important parameters are the dependence of the emission on the radial coordinate and the angle between the normal to the disk plane and the view line of a distant observer. Nevertheless, for a wide range of the parameters the shadow can be considered as a circle and its diameter is approximated by the expression (see [10], [11]):

\[ \theta_{\text{shadow}} \sim 10.4 \frac{r_g}{D_A}, \]

where \( r_g \) is the gravitational radius (here \( r_g = GM/c^2 \), \( D_A \) – the angular distance to the black hole. Substituting the parameter values of the stellar black holes and the black holes presented in the central part of the distant galaxies and comparing \( \theta_{\text{shadow}} \), one can conclude that the SMBH shadows are more reliable objects for the observations than stellar black holes. For the black hole in the center of our Galaxy the estimation of the angular size of its shadow gives \( \theta_{\text{ring}} \approx 53 \) microsecond arc.

The angular distance depends on the parameters of the cosmological model and reaches the maximum \( D_A \approx 1750 \) Mpc (at \( z \approx 1.6 \)), for the Hubble constant \( H_0 = 70 \) km/(s·Mpc), the cosmological matter density \( \Omega_m = 0.3 \) and the \( \Lambda \)-term density 0.7. Having set the angular resolution of Millimetron (in interferometric mode) as an angular size of the shadow one can derive from (1) that Millimetron will detect all SMBHs with mass \( M > 10^9 M_\odot \) in the Universe if they are bright enough. The black hole of such mass can be called “hypermassive”. The mission will also detect the nearby SMBHs with lower masses.

Despite the absence of published observations of black hole shadows, they are already planned to be used for testing of the General Relativity in strong gravitational fields (see, for example [12]). The theorem on the “absence of hair” will be apparently the key point in the verification of General Relativity. The experts associate the special hopes with observations in millimeter and submillimeter bands ([10, 13]). The observations in the submillimeter
range have the privilege because the influence of the scattering processes in interstellar and intergalactic medium decreases with increasing the frequency, see [14]. This is extremely important for the image reconstruction procedure in the interferometric observations.

II. CATALOG STRUCTURE

By now there are several SMBH catalogs. The main ones are (in order of publication): [15], [16], [17] and [18].

The content and format of the catalogs were determined by the tasks and requirements of researchers. The original purpose of creating our catalog was to select the SMBH, the shadows of which could be resolved by space observatory Millimetron. This imposes the restrictions not only on the angular size of SMBH, but also on their celestial coordinates and fluxes in the frequency channels of Millimetron. The table with 20 best candidates for observations presented in [19].

It is planned that the Millimetron Observatory will operate in wide frequency bands centered at 22, 43, 100, 240 and 350 GHz and, optionally, at 600 and 800 GHz ([20]). As we work with the published data, it turned out that for a large number of SMBHs the total emission fluxes in these bands are unknown. For some sources, the nearest measured points are spaced by several orders of magnitude in frequency. For this reason, and also because of a possible change of the Millimetron orbit, we decided that it is necessary to compile as complete catalog of SMBH as possible.

At present, the observations of black hole shadows are also planned for other telescopes. The most promising project is the Event Horizon Telescope (EHT)\(^2\), which is the array of several observatories operating in the interferometer mode. Due to the larger area of the receiving antennas, the sensitivity of such an interferometer is better than that of the Millimetron, but its angular resolution is fundamentally limited by the Earth diameter. Given this limitation, the list of shadows available for the observation consists of only a few objects. First of all, it is a black hole in the center of the Galaxy, known as the source of Sgr A* and the active nucleus of M87 galaxy. The expected angular sizes of these shadows differ by a factor of two; they are approximately 50 and 20 microseconds arc.

\(^2\) EHT – Event Horizon Telescope. [http://eventhorizontelescope.org](http://eventhorizontelescope.org)
The proposed catalog of SMBH includes 353 objects. This is much more than the preliminary list of 20 sources mentioned above. This is due to both the small angular size of most of the known SMBH, and the absence of any information on flows from these objects in the submillimeter range.

The catalog is available in website: http://millimetron.ru/index.php/en/scientific-program/the-catalog-of-supermassive-black-holes. It is organized as follows.

A. Source name

The first column shows the source name. Sometimes the object has one or more synonyms, which are also presented. This can help find the object in the astronomical databases. As one can see from the names of the SMBH, some of them are the nuclei of nearby galaxies and some are active galactic nuclei (QSOs and Seyfert galaxies).

B. SMBH mass

The second column shows the mass of the black hole in the units of $10^8 M_\odot$. We call this quantity as a “mass parameter”.

As it follows from the table, the range of object masses is rather large. The most massive single SMBH has the mass parameter of more than 100, while the lower mass boundary of the SMBH, by definition, is not less than $10^{-4}$. For a number of black holes, there are several measurements of mass, which differ by a factor of 5. The statistical error differs from object to object and for the majority of SMBH is about 30%. For individual objects the uncertainty of the mass measurement could reach a few order of magnitude. For 15% of the SMBHs, only the upper estimation of the mass is available.

Today there are several ways to determine the black hole mass: the dynamics of stars, gas dynamics, masers, reverberation method ([1]) and a number of statistical methods. Another method was proposed in [1], in terms of the angular size of the black hole shadow. For obvious reason this method has never been used yet.

The histogram in Fig. [1] represents the distribution of SMBH mass. The normalized number of SMBHs is shown here as a function of a “mass parameter”.
C. Distance to the object

The third column of the catalog shows the distance to the object, expressed in megaparsecs.

As it is known a few types of distance are used in cosmology. They are: the metric distance, the distance based on luminosity, the same based on the angular scale and the distance based on the redshift of the object. In SMBH catalogs the type of the distance representation is not usually indicated, but the metric distance is traditionally used.

Our catalog is intended to the observation of the black hole shadows. So, we prefer the angular distance because it is the one which we use to evaluate the angular scale of the shadow. It is easy to evaluate the distance according to the angular scale if we know the redshift of the emission source and accept the cosmological model. The following set of parameters has been used: the Hubble constant $H_0 = 70 \text{ km}/(\text{s} \cdot \text{Mpc})$, the cosmological matter density $\Omega_m = 0.3$, the $\Lambda$-term density $\Omega_\Lambda = 0.7$. These values of the parameters differ somewhat from so-called “post-Planckian” cosmological parameters, but using of the latter would be excessively accurate.

The histogram in Fig. 2 demonstrates the averaged number of SMBH in spherical layer as
function of its angular distance $D_A$. The distance step on this histogram is not constant (1-10, 10-25, 25-50, 50-100, 100-150, 150-200, 200-300, 300-500, 500-1000 and 1000-1750 Mpc) and this may cause some inconvenience.

![Histogram of Angular Distance](image)

**FIG. 2:** Averaged number of SMBH in spherical layer as function of its angular distance.

### D. Angular size of SMBH

The fourth column indicates the angle at which the gravitational radius of the black hole should be observed, expressed in arc microseconds. We emphasize that this is the gravitational radius in the context of expression (1) and the angular size of the shadow is about 10 times larger. Fig. 3 shows the percentage of SMBH as function of its angular size of gravitational radius.

### E. Object coordinates

In the fifth and sixth columns, the coordinates of the SMBHs are given in the equatorial coordinate system for the J2000 epoch. For most sources we limited the accuracy of coordi-
FIG. 3: Percentage of SMBH as function of its angular size of gravitational radius.

nates to one second arc. This is more than enough to determine the projection of the base when planning the interferometric observations of the shadows.

F. Frequency

The seventh column shows the central frequencies of the channels (expressed in gigahertz) in which the SMBHs were observed. Since our catalog is “sharpened” for the interferometric observations of shadows in the millimeter and submillimeter ranges, where no significant self-absorption of the radiation is expected, we tried to work at the frequency range of 22 – 800 GHz. However, for some sources, there were few observation points, in this case we cataloged the data with near frequencies. For example, the source PG 0052+251 has not currently observational data within the interval 22 – 800 GHz, so we provide data for the near frequencies, 9 and 1764 GHz.
G. Total flux from SMBH

The eighth column contains the data of the magnitude of radiation fluxes at the corresponding frequencies. The flux values are expressed in Jansky. The main, but not the only source of information on the fluxes was the public database NED\(^3\). If a number of observations (at different time and with different receiving equipment) were carried out for the frequency channel of interest, we indicated the range of the observed quantities. It should be noted that these fluxes characterize not the SMBH itself, but cover the larger area than the size of shadow. The reason for this is obvious: until now a few objects have been observed in the required frequency range with a really high angular resolution, comparable with the size of the gravitational radius of SMBH. Therefore, the actual value of the flux will, of course, be less, than indicated in the Catalog.

H. Comment

The last column of the table contains the reference to the source catalog (catalogs) and/or to the published article.

III. SUBCATALOGS

Two more subcatalogs for future interferometric observations presented in Tables I and II. The first of them (Table I) summarizes the top 25 black holes ordered descending by their mass parameter. One more selection presented in Table II, where summarized the top 25 SMBHs with highest angular size. Some objects (NGC 4889, NGC 1600) are included in both subcatalogs.

IV. CONCLUSION

As it follows from the available data, the observation of any representative image of a black hole shadow is a very difficult task: on the one hand it is necessary that the source appears bright enough at the frequency of the intended observations, on the other hand, its

\(^3\) http://ned.ipac.caltech.edu/
angular scale should be several times greater than the angular resolution of the interferometer at the same frequency.

In this situation, it is encouraging that for a large number of sources the fluxes in the submillimeter range remain unknown yet and some of them may appear bright enough.

The catalog of supermassive black holes, which we present here is intended for use in the planning of the interferometric observations of SMDM shadows in the submillimeter and millimeter ranges. It is available in website of Astro Space Center of P. N. Lebedev Physical Institute of Russian Academy of Sciences: [http://millimetron.ru/index.php/en/scientific-program/the-catalog-of-supermassive-black-holes](http://millimetron.ru/index.php/en/scientific-program/the-catalog-of-supermassive-black-holes).

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TABLE I: Top 25 supermassive black holes in the Catalog

| Object          | $M$, $10^8 M_\odot$ | $D_A$, Mpc | Angular size, $\mu$sec arc | Right ascension, h. m. s. | Declination, deg. | Frequency, GHz | Flux, Jy | Reference |
|----------------|---------------------|------------|-----------------------------|---------------------------|-------------------|----------------|---------|-----------|
| S5 0014+81     | 400                 | 1531       | 0.26                        | 00 17 08.5                | + 81 35 08        | 15             | 0.47-0.916 | [21]      |
| H1821+643      | 300                 | 912 (z)    | 0.32                        | 18 21 57.3                | + 64 20 36        | 93             | 0.01     | [22]      |
| APM 08279+5255 | 230                 | 1447 (z)   | 0.16                        | 08 31 41.7                | + 52 45 18        | 100            | 0.001    | [23]      |
| IRAS F08279+5255 | 100             | 1447(z)    | 0.07                        | 08 31 41.7                | + 52 45 18        | 100            | 0.001    | [23]      |
| NGC 4889       | 210                 | 103        | 2.01                        | 13 00 08.13               | + 27 58 37.2      | 2.4            | <0.069   | [16]      |
| SDSS J074521.78+734336.1 | 195             | 1554 (z)   | 0.13                        | 07 45 21.78               | + 73 43 36.1      | in NED         |          | [26]      |
| OJ 287         | 180                 | 930        | 0.19                        | 08 54 48.88               | + 20 06 39.6      | 22-23          | 2.4-6.1  | [27]      |
| NGC 1600       | 170                 | 64         | 2.6                         | 04 31 39.9                | - 05 05 10.0      | 5              | 0.016    | [18]      |
| SDSS J080819.69+373047.3 | 151             | 1513 (z)   | 0.10                        | 08 08 19.69               | + 37 30 47.3      | 14000          | 0.002    | [26]      |
| 1 | 2  | 3        | 4  | 5            | 6            | 7     | 8     | 9     |
|---|----|----------|----|--------------|--------------|-------|-------|-------|
| SDSS J115954.33+201921.1 | 141 | 1522 (z) | 0.09 | 11 59 54.33  | + 20 19 21.1 | 325000 | 0.0006 | 26    |
| SDSS J080430.56+542041.1 | 135 | 1470 (z) | 0.09 | 08 04 30.56  | + 54 20 41.1 | 14000  | 0.004  | 26    |
| SDSS J01100+2802          | 124 | 1146 (z) | 0.10 | 01 00 13.02  | - 28 02 25.8 |       | in NED absent | 28    |
| SDSS J075303.34+423130.8 | 123 | 1496 (z) | 0.08 | 07 53 03.34  | + 42 31 30.8 | 30    | 0.058  | 26    |
| SDSS J081855.77+095848.0 | 120 | 1479 (z) | 0.08 | 08 18 55.77  | + 09 58 48.0 | 14000  | 0.007  | 25    |
| SDSS J082535.19+512706.3 | 112 | 1508 (z) | 0.07 | 08 25 35.19  | + 51 27 06.3 | 14000  | 0.004  | 25    |
| SDSS J013127.34-032100.1 | 110 | 1273 (z) | 0.09 | 01 31 27.34  | - 03 21 00.1 |       | in NED absent | 29    |
| Holmberg 15A (10-3100)   | 100 | 224 (z)  | 0.45 | 00 41 50.5   | - 09 18 11   | 22.5   | 0.002  | 30    |
| PKS 2126-158             | 100 | 1546     | 0.06 | 21 29 12.2   | - 15 38 41   | 20-24  | 1.07-0.84 | 21    |

TABLE I: Top 25 supermassive black holes in the Catalog (continued)
|   | 1   | 2    | 3    | 4     | 5     | 6     | 7     | 8     | 9     |
|---|-----|------|------|-------|-------|-------|-------|-------|-------|
| PSO O334.2028 +01.4075 | 100 | 1720 (z) | 0.06 | 22 16 48.6 | + 01 24 27 | in NED absent | orb. per. 542 days | 32, dbl. BH. |
| SDSS J015741.57 -010629.6 | 98  | 1499 (z) | 0.07 | 01 57 41.57 | - 01 06 29.6 | in NED absent | 26 |
| NGC 3842 97 | 98  | 98.4 | 0.97 | 11 44 02.15 | + 19 56 59.3 | 2.4 3000 | 0.022 | 16 |
| NGC 3842 91 | 92.2 | 0.97 | 11 44 02.15 | + 19 56 59.3 | 2.4 3000 | 0.022 | 16 |
| SDSS J230301.45 -093930.7 | 91  | 1511 (z) | 0.06 | 23 03 01.45 | - 09 39 30.7 | 325000 | 0.0004 | 26 |
| NGC 5419 72 | 56.2 | 1.27 | 14 03 38.7 | - 33 58 42 | 5 1900 | 0.09-0.12 < 0.021 | 17, 18 |
| CID-947 69 | 1537 (z) | 0.04 | 10 01 11.35 | + 02 08 55.6 | 100 300 | 0.0001 0.003 | 21 |
TABLE II: Top 25 supermassive black holes ranked on angular size

| Object   | $M$, $10^8M_\odot$ | $D_A$, Mpc | Angular size, μsec arc | Right ascension, h. m. s. | Declination, deg. | Frequency, GHz | Flux, Jy | Reference |
|----------|---------------------|------------|------------------------|---------------------------|-------------------|----------------|---------|-----------|
| Sgr A* | 0.041 0.0431 | 0.008 0.00833 | 5.06 5.11 | 17 45 40.02 43 | 29 00 28.17 100 | 1.3-1.9 2.1-2.4 | 1.3-1.9 2.1-2.4 | [15], [16] |
| NGC 4486 | 36 | 17 | 2.09 | 12 30 49.42 +12 23 28.0 | 22-23 | 0.5-21 | 0.5-21 | [15] |
| M 87 | 63 | 17 | 3.66 | 12 30 49.42 +12 23 28.0 | 22-23 | 0.5-21 | 0.5-21 | [15] |
| NGC 4649 | 21 | 16.5 | 1.23 | 12 43 40.4 +11 33 10 | 10.5 | 1700 | < 0.1 | [16], [17], [18] |
| M 60 | 47 | 16.5 | 2.81 | 04 31 39.9 -05 05 10.0 | 5 | 3000 | 0.190 | [16], [17], [18] |
| NGC 1600 | 170 | 64 | 2.6 | 04 31 39.9 -05 05 10.0 | 5 | 3000 | 0.190 | [16], [17], [18] |
| NGC 4889 | 210 | 103 | 2.01 | 13 00 08.13 +27 58 37.2 | 2.4 | 3000 | < 0.069 | [16], [17], [18] |
| NGC 224 | 1.5 | 0.8 | 1.85 | 00 42 44.35 +41 16 08.6 | 5 | 1900 | 7800 | [16], [17], [18] |
| M 31 | 1.4 | 0.77 | 1.80 | 00 42 44.35 +41 16 08.6 | 5 | 1900 | 7800 | [16], [17], [18] |
| NGC 1407 | 45 | 28 | 1.6 | 03 40 11.8 -18 34 48 | 5 | 1900 | 0.092 | [16], [17], [18] |
| NGC 4472 | 25 | 17.1 | 1.44 | 12 29 46.7 +08 00 02 | 15 | 96 | 0.15 | [17], [18] |
| M 49 | 25 | 17.1 | 1.44 | 12 29 46.7 +08 00 02 | 15 | 96 | 0.15 | [17], [18] |
| NGC 3706 | 59 | 46 | 1.3 | 11 29 44.4 -36 23 29 | 5 | 1900 | < 0.022 | [16], [17], [18] |
| NGC 3923 | 28 | 20.9 | 1.3 | 11 51 01.7 -28 48 22 | 5 | 1900 | 0.001 | [17], [18] |
TABLE II: Top 25 supermassive black holes ranked on angular size (*continued*)

|   | 1   | 2  | 3   | 4    | 5       | 6                   | 7    | 8          | 9  |
|---|-----|----|-----|------|---------|---------------------|------|------------|----|
| NGC 5419 | 72  | 56.2 | 1.27 | 14 03 38.7 | - 33 58 42 | 5 | 0.09-0.12 | [17], [18] |
| NGC 3842 | 97  | 94.8 | 0.97 | 11 44 02.15 | + 19 56 59.3 | 2.4 | 0.022 | [16] |
|          | 91  | 92.2 | 0.97 |                   |            | 3000 | 1.49 | [17], [18] |
| NGC 5055 | 8.3 | 8.7  | 0.94 | 13 15 49.3 | + 42 01 45 | 15 | < 0.001 | [18] |
|          |     |      |      |                   |            | 300 | 1.3 |           |
|          |     |      |      |                   |            | 600 | 2.6 |           |
|          |     |      |      |                   |            | 850 | 64 |           |
| NGC 3115 | 9.6 | 10.2 | 0.93 | 10 05 14.0 | - 07 43 06.9 | 1.4 | 0.0006 | [15], [16] |
|          | 9.0 | 9.5  | 0.94 |                   |            | 1900 | < 0.045 | [17] |
|          | 8.8 | 9.5  | 0.91 |                   |            |       | [18] |
| IC 1459  | 28  | 30.9 | 0.89 | 22 57 10.61 | - 36 27 44.0 | 20 | 0.55 | [15], [16] |
|          | 25  | 28.9 | 0.85 |                   |            | 95  | 0.26 | [17], [18] |
|          |     |      |      |                   |            | 1800| 1.1-2.4|           |
| NGC 4374 | 15  | 17.0 | 0.87 | 12 25 03.74 | + 12 53 13.14 | 15 | 0.16-1.3 | [15] |
| M 84     | 8.5 | 17.0 | 0.49 |                   |            | 43  | 0.1  | [16] |
|          | 9.2 | 18.5 | 0.49 |                   |            | 95-100 | 0.14-0.17 | [17] |
|          | 9.3 | 18.5 | 0.50 |                   |            | 350 | 0.15 | [18] |
|          |     |      |      |                   |            | 670 | 0.12 |           |
| NGC 1550 | 37  | 51.6 | 0.72 | 04 19 37.9 | + 02 24 34 | 2.3 | 0.008 | [17], [18] |
|          |     |      |      |                   |            | 3000 | < 0.245 |           |
| NGC 5328 | 47  | 64.1 | 0.72 | 13 52 53.3 | - 28 29 22 | 5 | < 0.0009 | [17], [18] |
|          |     |      |      |                   |            | 3000 | < 0.07 |           |
| NGC 6861 | 20  | 27.3 | 0.72 | 20 07 19.5 | - 48 22 13 | 0.8 | 0.015 | [17], [18] |
|          |     |      |      |                   |            | 3000 | 3-3.5 |           |
| NGC 3091 | 36  | 51.3 | 0.70 | 10 00 14.3 | - 19 38 13 | 5 | 0.007 | [17], [18] |
|          |     |      |      |                   |            | 12500 | 0.003 |           |
| NGC 4594 | 5.7 | 10.3 | 0.55 | 12 39 59.43 | -11 37 23.0 | 20 | 0.08 | [15] |
| M 104    | 5.3 | 10.3 | 0.51 |                   |            | 250 | 0.19-0.44 | [16] |
| Sombrero | 6.7 | 9.9  | 0.67 |                   |            | 350 | 0.24-0.92 | [17] |
|          | 6.6 | 9.9  | 0.67 |                   |            | 1000| 0.6-1.2 | [17] |
TABLE II: Top 25 supermassive black holes ranged on angular size (continued)

|   | 1   | 2   | 3   | 4   | 5            | 6                | 7        | 8        | 9       |
|---|-----|-----|-----|-----|--------------|------------------|----------|----------|---------|
|   | NGC 5128 |     |     |     | 3 4.4 0.67 13 25 27.61 | 43 10 08.8 | 22 3-112 | [15], [16] |         |
|   | Cen A  | 0.7 | 4.4 | 0.16| 41 32-72 | 90-93 41 | 230-240 5.8-6 | [15], [16] | [15], [16] |
|   |        | 0.57| 3.62| 0.16|          | 350 18 |          | [15], [16] | [17], [18] |
|   | NGC 1277 | 47  | 71  | 0.65| 03 19 51.49 + 41 34 24.7 | 3000 < 0.7 | [15], [16] |         |
|   | NGC 1332 | 14.5| 22.3| 0.64| 03 26 17.321 - 21 20 07.33 | 5 0.005 | [15], [16] |         |
|   |        | 6.8 | 22.3| 0.30|          | 1700 1.56 | [15], [16] |         |
|   | NGC 1399 | 5.1 | 21.1| 0.24| 03 38 29.08 - 35 27 02.67 | 8.5 0.36 | [15], [16] |         |
|   |        | 13  | 21.1| 0.61|          | 1875 0.02 | [15], [16] |         |
|   |        | 8.8 | 20.9| 0.42|          |          | [15], [16] |         |
|   |        | 8.7 | 20.9| 0.41|          |          | [15], [16] |         |