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МУНДАРИЖА | СОДЕРЖАНИЕ | CONTENT

1. Elliptik Galaktikalarning Markaziy Supermassiv Qora O‘ra Massasi Va Fizik Parametrlari O‘rtasidagi Bog‘liqlikning Statistik Tahlili.....	4
Ismatova L. Ilhom qizi Shohruxbek R. Xudayberganov Farxodjon O‘. BOTIROV	

Statistical Analysis Of The Relationship Between The Central Supermassive Black Hole Mass And The Physical Parameters Of Elliptical Galaxies

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Abstract: Using a combined catalog of 119 elliptical galaxies compiled from observational data published in 2009–2025, we statistically analyze the relationship between the central supermassive black hole mass ($\text{Log}M_{\text{BH}}$) and the main physical parameters of the host galaxies. $\text{Log}M_{\text{BH}}$ shows a strong positive correlation with the stellar velocity dispersion (σ) and bulge mass ($r \approx 0.82$), a significant correlation with bulge luminosity ($r \approx 0.73$), and a moderate correlation with the total stellar mass ($r \approx 0.54$). The results indicate an evolutionary link between elliptical galaxies and their central black holes.

Keywords: elliptical galaxies, supermassive black holes, central black hole mass, stellar velocity dispersion, bulge mass.

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Elliptik Galaktikalarning Markaziy Supermassiv Qora O‘ra Massasi Va Fizik Parametrlari O‘rtasidagi Bog‘liqlikning Statistik Tahlili

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O‘zR FA Astronomiya instituti laboratoriya mudiri, f.-m.f.d. (DSc) K.T.Mirtadjiyeva taqrizi asosida

Annotatsiya: Maqolada 2009–2025-yillarda nashr etilgan kuzatuv ma’lumotlari asosida tuzilgan 119 ta elliptik galaktikadan iborat jamlanma katalog yordamida markaziy supermassiv qora o‘ra massasi ($\text{Log}M_{\text{BH}}$) bilan galaktikaning asosiy fizik parametrlari o‘rtasidagi bog‘liqlik statistik tahlil qilindi. $\text{Log}M_{\text{BH}}$ tezlik dispersiyasi (σ) va balj massasi bilan kuchli ($r \approx 0,82$), balj yorqinligi bilan sezilarli ($r \approx 0,73$), umumiy yulduz massasi bilan esa o‘rtacha ($r \approx 0,54$) musbat korrelyatsiyaga ega ekani aniqlandi. Natijalar elliptik galaktikalar va ularning markaziy qora o‘ralari evolyutsiyasi o‘zaro bog‘liq ekanini ko‘rsatadi.

Kalit so‘zlar: elliptik galaktikalar, markaziy supermassiv qora o‘ra, qora o‘ra massasi, tezlik dispersiyasi, balj massasi.

Статистический Анализ Взаимосвязи Между Массой Центральной Сверхмассивной Чёрной Дыры И Физическими Параметрами Эллиптических Галактик

Аннотация: На основе сводного каталога из 119 эллиптических галактик, составленного по наблюдательным данным публикаций 2009–2025 гг., статистически проанализирована связь массы центральной сверхмассивной чёрной дыры ($\text{Log}M_{\text{BH}}$) с основными физическими параметрами галактик. Выявлена сильная положительная корреляция $\text{Log}M_{\text{BH}}$ с дисперсией скоростей (σ) и массой балджа ($r \approx 0,82$), значимая — со светимостью балджа ($r \approx 0,73$) и умеренная — с общей звёздной массой ($r \approx 0,54$). Результаты указывают на эволюционную взаимосвязь эллиптических галактик и их центральных чёрных дыр.

Ключевые слова: эллиптические галактики, центральная сверхмассивная чёрная дыра, масса чёрной дыры, дисперсия скоростей, масса балджа.

Introduction. At present, observational data on the central supermassive black holes of elliptical galaxies have been reported by numerous authors. Based on observational data published in scientific papers between 2009 and 2025, a combined catalog of elliptical galaxies was compiled. Using this catalog, a statistical analysis was performed to investigate the relationships between the masses of the central supermassive black holes and the physical parameters of the host elliptical galaxies. The analysis revealed significant correlations between the central supermassive black hole mass and several physical properties of elliptical galaxies. In addition, histograms were constructed to examine the distributions of the principal physical parameters.

Literature Review. The relationship between the masses of supermassive black holes and the physical parameters of their host galaxies is one of the important areas of modern astrophysical research. Kormendy and Ho [1] summarized the relationship between black hole mass and the evolutionary properties of galaxies. Graham [3] investigated the relationship between black hole mass and stellar velocity dispersion, while Hu [5] examined the correlation between black hole mass and bulge mass. Beifiori et al. [6] estimated supermassive black hole masses based on observational data. Dullo et al. [2] investigated the relationship between black hole mass and the photometric properties of galaxies. Farrah et al. [9] analyzed the growth of supermassive black holes in elliptical galaxies.

Previous studies have primarily focused on the relationships between black hole mass and individual physical parameters. In the present study, a combined catalog of 119 elliptical galaxies was compiled using data obtained from various observational sources. The correlations between the central supermassive black hole mass, stellar velocity dispersion, total stellar mass, bulge mass, and bulge luminosity are investigated using a comprehensive statistical analysis.

Research Methodology. The study included 119 elliptical galaxies selected based on observational data published between 2009 and 2025. The analyzed parameters include the central supermassive black hole mass ($\text{Log}M_{\text{BH}}$), stellar mass ($\text{Log}M_*$), bulge mass ($\text{Log}M_{\text{bulge}}$), bulge luminosity ($\text{Log}L_{\text{bulge}}$), stellar velocity dispersion (σ), and the apparent diameter of the galaxy.

The primary method employed in this study is statistical correlation analysis, which was used to evaluate the relationships between the central supermassive black hole mass and the main physical parameters of the host galaxies. The relationships between the parameters were quantitatively characterized using correlation coefficients. The obtained results were analyzed using graphical and statistical methods to identify the relationships between the black hole mass and the physical properties of the host elliptical galaxies.

Analysis and results. The histograms presented below illustrate the distributions of the total stellar mass ($\text{Log}M_*$), stellar velocity dispersion (σ), bulge mass ($\text{Log}M_{\text{bulge}}$), and central supermassive black hole mass ($\text{Log}M_{\text{BH}}$) for the sample of elliptical galaxies.

The histogram of the total stellar mass distribution shows that elliptical galaxies with a total stellar mass of approximately $\text{Log}M_* = 11.8 M_{\odot}$ constitute the largest fraction of the sample, whereas galaxies with $\text{Log}M_* = 10 M_{\odot}$ and $\text{Log}M_* = 12.4 M_{\odot}$ occur relatively less frequently (Fig. 1).

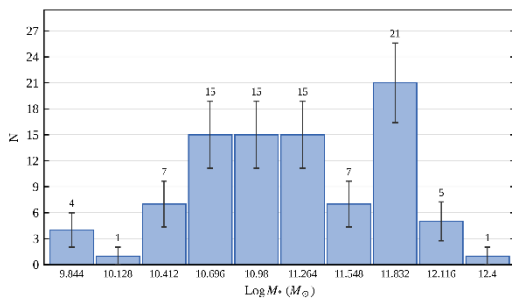


Fig. 1. Histogram of the Total Stellar Mass Distribution of Elliptical Galaxies

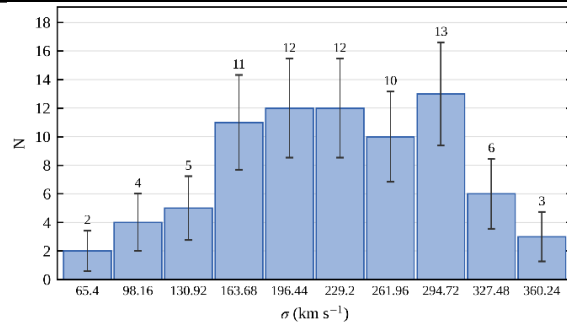


Fig. 2. Histogram of the Stellar Velocity Dispersion Distribution of Elliptical Galaxies

The histogram of the stellar velocity dispersion shows that elliptical galaxies with a velocity dispersion of $\sigma = 295 \text{ km s}^{-1}$ are the most common in the sample, whereas galaxies with $\sigma = 65.4 \text{ km s}^{-1}$ occur relatively infrequently (Fig. 2).

The histogram of the central supermassive black hole mass distribution indicates that elliptical galaxies with $\text{Log} M_{\text{BH}} \approx 8.5 M_\odot$ are the most common in the sample, whereas galaxies with $\text{Log} M_{\text{BH}} \approx 6.39 M_\odot$ are the least common (Fig. 3).

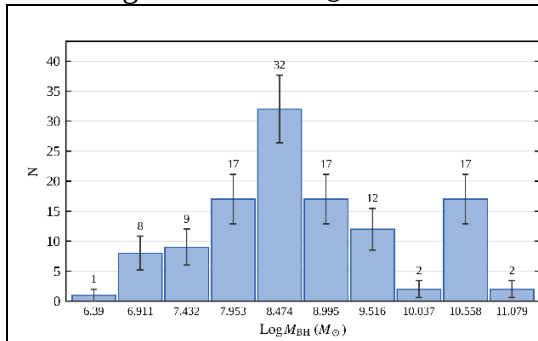


Fig.3. Histogram of the Central Supermassive Black Hole Mass Distribution of Elliptical Galaxies

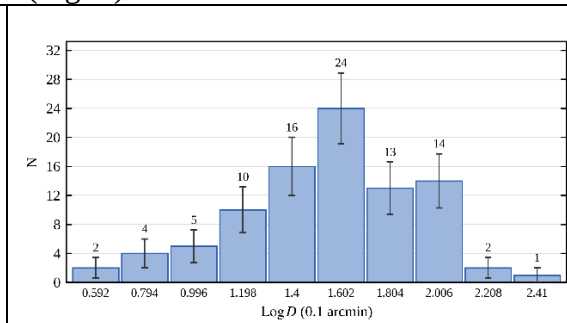


Fig. 4. Histogram of the apparent diameters of elliptical galaxies.

The apparent diameters of the elliptical galaxies show that galaxies with a value of $\text{Log} D = 1.6 \pm 0.1 \text{ arcmin}$ are the most frequently observed, whereas elliptical galaxies with $\text{Log} D = 2.41 \pm 0.1 \text{ arcmin}$ are less common (Figure 4).

Correlations between the central black hole masses of elliptical galaxies and their physical parameters were calculated (Table 1), and graphs illustrating these relationships were constructed based on the obtained correlation coefficients.

Table 1. Correlation coefficients between the central black hole mass and physical parameters.

Parameters	σ	Log M_*	Log M_{bulge}	Log L_{bulge}
Log M_{BH}	0.82	0,54	0,82	0,73

A linear relationship can be observed between the central black hole mass ($\text{Log} M_{\text{BH}}$) and the velocity dispersion (σ) of elliptical galaxies (Fig.5). As the central black hole mass ($\text{Log} M_{\text{BH}}$) increases, the bulge luminosity ($\text{Log} L_{\text{bulge}}$) of elliptical galaxies also increases (Figure 6). A nearly linear relationship is observed between the central black hole mass ($\text{Log} M_{\text{BH}}$) and the total stellar mass ($\text{Log} M_*$), as shown in Fig.7. Furthermore, with increasing central black hole mass ($\text{Log} M_{\text{BH}}$), the bulge mass ($\text{Log} M_{\text{bulge}}$) of elliptical galaxies also increases approximately linearly (Fig. 8).

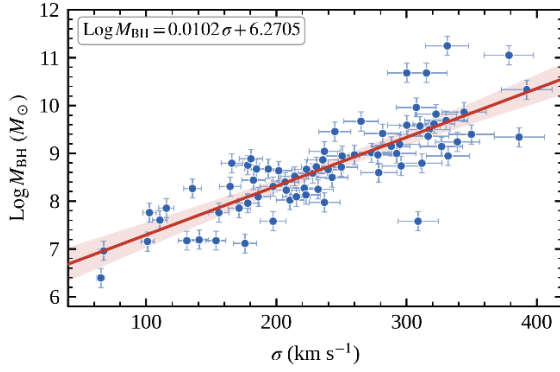


Fig. 5. Relationship between black hole mass and velocity dispersion.

$$\text{Log } M_{\text{BH}} = 0.0102\sigma + 6.2705 \quad (1)$$

$$\text{Log } M_{\text{BH}} = 0.9143 \text{Log } L_{\text{bulge}} - 1.4862 \quad (2)$$

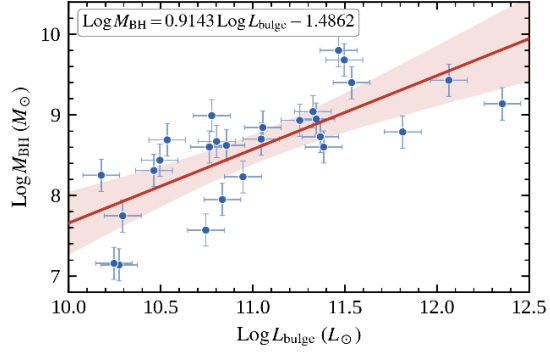


Fig. 6. Relationship between black hole mass and bulge luminosity.

The above equations indicate that, with increasing central black hole mass in elliptical galaxies, both bulge luminosity and velocity dispersion also increase in a nearly linear manner.

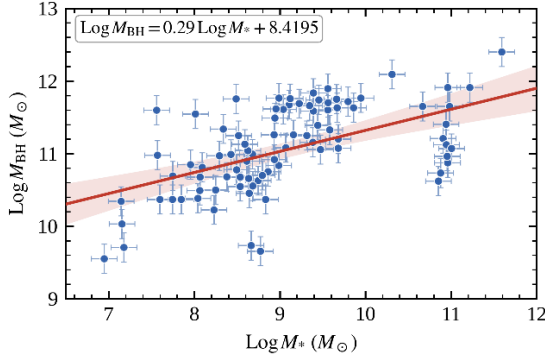


Fig. 7. Relationship between black hole mass and total stellar mass.

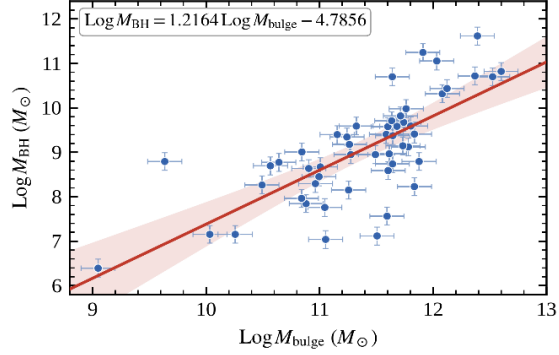


Fig. 8. Relationship between black hole mass and bulge mass.

$$\text{Log } M_{\text{BH}} = 0.29 \text{Log } M_* + 8.4195 \quad (3)$$

$$\text{Log } M_{\text{BH}} = 1.2164 \text{Log } M_{\text{bulge}} - 4.7856 \quad (4)$$

The above equations indicate that, with increasing central black hole mass in elliptical galaxies, both the total stellar mass and the bulge mass also increase in a nearly linear manner.

Conclusion

1. A combined catalog comprising 119 elliptical galaxies was compiled. Statistical analyses were performed to investigate the relationships between the central black hole masses and selected physical parameters provided in the catalog.

2. Based on the statistical analysis, correlation coefficients between the physical parameters of elliptical galaxies were determined (Table 1). The histograms of the physical parameters indicate that the most frequently occurring objects have a total stellar mass of $\text{Log } M_* = 11.8$, a velocity dispersion of $\sigma = 295 \text{ km s}^{-1}$, an apparent diameter of $\text{Log } D = 1.6 \pm 0.1 \text{ arcmin}$, and a central black hole mass of $\text{Log } M_{\text{BH}} = 8.5$.

3. Elliptical galaxies are characterized by relatively high central black hole masses ($\text{Log } M_{\text{BH}} \approx 8.5$), suggesting that these systems are generally associated with advanced stages of galaxy evolution.

4. The relationships among the physical parameters of elliptical galaxies are relatively strong and well ordered, whereas those observed in spiral galaxies tend to be more scattered and complex.

5. In elliptical galaxies, the central black hole can act as a quenching agent, suppressing or regulating star formation and thereby influencing the subsequent evolutionary development of the host galaxy.

References

1. Kormendy, J., & Ho, L. C. (2013). Coevolution (or not) of supermassive black holes and host galaxies. *Annual Review of Astronomy and Astrophysics*, 51, 511–653.
2. Dullo, B. T., Bouquin, A. Y. K., Gil de Paz, A., Knapen, J. H., & Gorgas, J. (2020).
3. Graham, A. W. (2008). Populating the galaxy velocity dispersion–supermassive black hole mass diagram: A catalogue of (MBH, σ) values. *Publications of the Astronomical Society of Australia*, 25, 167–175.
4. Botirov, F., & Nuritdinov, S. (2022). *Problems of formation and evolution of bulges of spiral galaxies*.
5. Hu, J. (2009). The black hole mass–bulge mass correlation: Bulges versus pseudo-bulges. *Monthly Notices of the Royal Astronomical Society*, 386(4), 2242–2252.
6. Beifiori, A., Sarzi, M., Corsini, E. M., Bontà, E. D., Pizzella, A., Coccatto, L., & Bertola, F. (2009).
7. Khonji, N., Gualandris, A., Read, J. I., & Dehnen, W. (2025). Black hole dragging: A new mechanism for forming nuclear star clusters in giant elliptical galaxies. *The Astrophysical Journal*, 994, 177.
8. Dominiak, P., Bureau, M., Davis, T. A., Ma, C.-P., Greene, J. E., & Gu, M. (2024). The MASSIVE Survey – XIX. Molecular gas measurements of the supermassive black hole masses in the elliptical galaxies NGC 1684 and NGC 0997. *Monthly Notices of the Royal Astronomical Society*, 529, 1597–1616.
9. Farrah, D., Petty, S., Croker, K. S., et al. (2023). A preferential growth channel for supermassive black holes in elliptical galaxies at $z \leq 2$. *The Astrophysical Journal*.
10. Tremaine, S., Gebhardt, K., Bender, R., et al. (2002). The slope of the black-hole mass versus velocity dispersion correlation. *The Astrophysical Journal*, 574(2), 740–753.
11. Davis, B. L., & Jin, Z. (2023). Discovery of a planar black hole mass scaling relation for spiral galaxies. *The Astrophysical Journal Letters*.

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