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FALSIFICATION OF GRAVITY THEORIES FROM THE FORM OF DARK SPOTS ON BLACK HOLE IMAGES

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Visual images of supermassive black holes M87* and SgrA* have been successfully registered recently by the international collaboration Event Horizon Telescope. This registration opens the unique possibility for verification (or falsification) of modified gravity theories in the strong filed limit when gravitational field is dominated over astrophysical factors. This verification is crucially important for physical interpretation of astrophysical and cosmological observations of the Universe and for understanding the physical origin of enigmatic dark matter and dark energy. The accuracy of Event Horizon Telescope is sufficient for demonstration of the quantitative agreement of the obtained dark spot images of both black holes with the General Relativity prediction. In particular, the forms of dark spots on the Event Horizon Telescope images correspond to the fast black hole rotation of the supermassive black holes M87* and SgrA*. Meantime, the Event Horizon Telescope accuracy is insufficient for the verification of the modified gravity theories. In the observable future this verification would be possible in realization of the international project of the Space Observatory Millimetron, which angular resolution in few orders of magnitude exceeds the corresponding one of the Event Horizon Telescope.

Keywords: gravitation, black holes, cosmology.

ФАЛЬСИФИКАЦИЯ ТЕОРИЙ ГРАВИТАЦИИ ПО ФОРМЕ ТЕМНЫХ ПЯТЕН НА ИЗОБРАЖЕНИЯХ ЧЕРНЫХ ДЫР

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Регистрация видимых изображений сверхмассивных черных дыр M87* и SgrA* международной коллаборацией Телескоп Горизонта Событий открывает уникальную возможность проверки различных модификаций Общей Теории Относительности в режиме сильного поля, когда гравитационное поле доминирует по сравнению с астрофизическими факторами. Такая проверка чрезвычайно важна для интерпретации астрофизических и космологических наблюдений Вселенной и для понимания физической природы темной материи и темной энергии. Точность Телескопа Горизонта Событий оказалась достаточной для качественного согласия полученных изображений темных пятен на изображениях двух черных дыр с предсказанием Общей Теории Относительности. В частности, формы темных пятен на изображениях Телескопа Горизонта Событий свидетельствуют о быстром вращении сверхмассивных черных дыр черных дыр M87* и SgrA*. Однако, точности Телескопа Горизонта Событий недостаточно для проверки модифицированных теорий гравитации. В обозримом будущем такая проверка станет возможной при реализации международного проекта Орбитальной Обсерватории Миллиметрон, угловое разрешение которого будет на несколько порядков выше, чем у Телескопа Горизонта Событий.

Ключевые слова: гравитация, черные дыры, космология.

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Visual images of supermassive black holes M87* and SgrA* have been successfully registered recently by the international collaboration Event Horizon Telescope [1, 2]. This registration opens

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the unique possibility for verification (or falsification) of modified gravity theories in the strong filed limit when gravitational field is dominated over astrophysical factors. This verification is crucially important for physical interpretation of astrophysical and cosmological observations of the Universe and for understanding the physical origin of enigmatic dark matter and dark energy.

The accuracy of Event Horizon Telescope is sufficient for demonstration of the qualitative agreement of the obtained dark spot images of both black holes with the General Relativity prediction [3–8]. In particular, the forms of dark spots on the Event Horizon Telescope images correspond to the fast black hole rotation of the supermassive black holes M87* and SgrA* [9, 10]. Meantime, the Event Horizon Telescope accuracy is insufficient for the verification of the modified gravity theories.

The observed dark spots are always projected inside the awaited position of the classical black hole shadow at the celestial sky. From physical point of view the classical black hole shadow is the capture cross-section of photons in the black hole gravitational field [11–13].

Physically reasonable model for the generation of strong energy emission from accreting black holes is based on the Blandford-Znajek mechanism [14], in which there is an electric current across the black hole event horizon. This electric current generates the electromagnetic flow with the Pointing vector along the black hole rotation axis and, additionally, provides the very strong heating of accreting matter in the very vicinity of black hole event horizon. This mechanism is fully justified by the numerical magnetohydrodynamics in the framework of General Relativity [15–21].

A recent accuracy of the Event Horizon Telescope is insufficient for the verification of modified gravity theories. In the observable future this verification would be possible in realization of the international project of the Space Observatory Millimetron with angular resolution in few orders of magnitude exceeding the corresponding one of the Event Horizon Telescope [22].

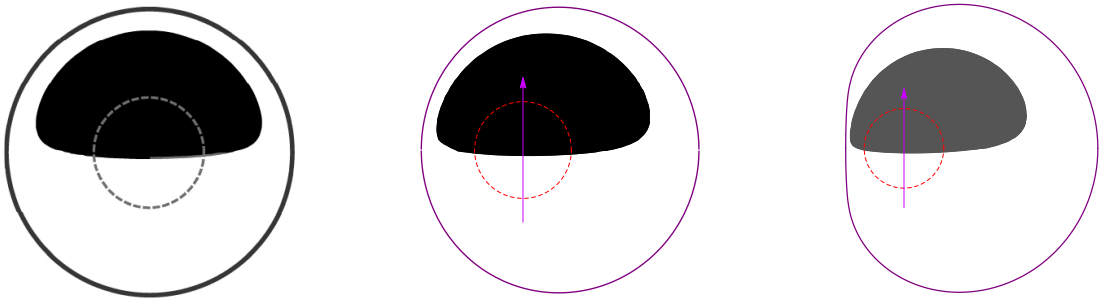

Fig. 1. Modeled dark spots (black regions) at the central part image of the supermassive black hole SgrA* with black hole spin values $a = 0$ (left panel) $a = 0.75$ (middle panel) and $a = 0.9982$ (right panel), respectively. The dashed rings are the imaginary sizes of black horizon globes in the Euclidean space with the absence of gravity. Arrows show the projection of the black hole rotation axes on the celestial sphere. For details see [7].

Fig. 1 demonstrates the modeled dark spots at the central part image of the supermassive black hole SgrA* with different black hole spin values. The outer closed curves are the boundaries of the classical black hole shadows projected at the celestial sphere.

Respectively, Fig. 2 shows the superposition of the Event Horizon Telescope image of supermassive black holes SgrA* and M87* with the modeled central dark spot for black hole spin values $a = 0.75$ in both cases.

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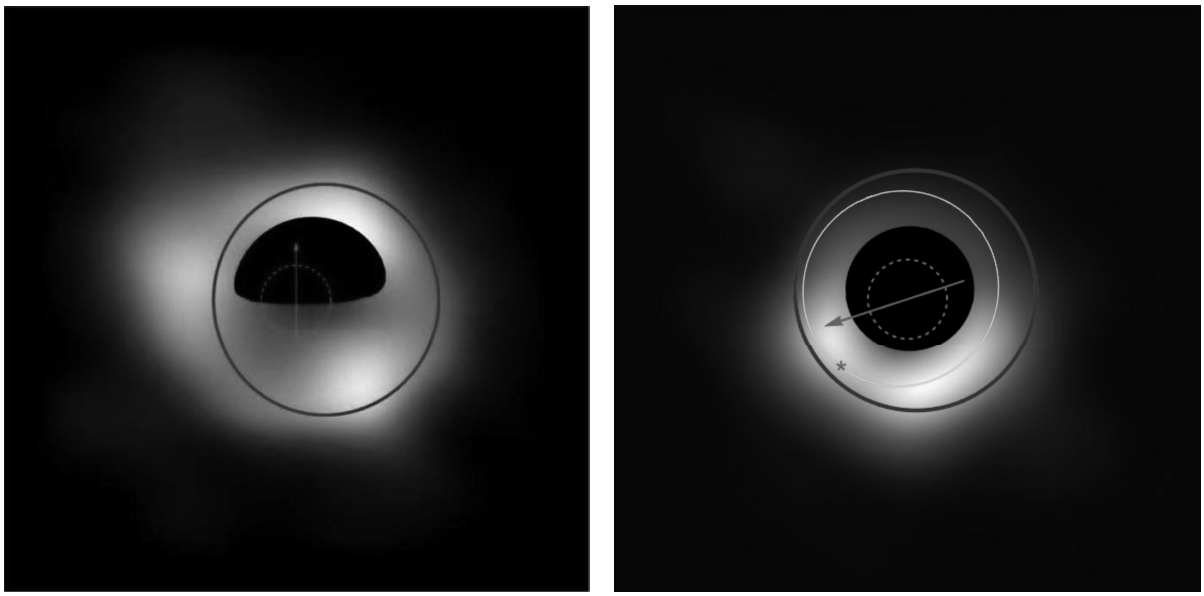

Fig. 2. Superposition of the Event Horizon Telescope images of supermassive black holes SgrA* (left panel) and M87* (right panel) with the modelled forms of dark spots (black region) for spin values $a = 0.75$ in both cases. The closed curve with a "star"is the brightest part of the thin accretion disk viewed by a distant observer. For details see [7].

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