Observations questioning classical GRT and preferring LI of GRT – EHT image of M87*, Spin, ALMA image of SGR A* and more

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Content

1 Preliminary remarks

This contribution is a continuation of "Measuring results of M87* and Lorentz interpretation (LI) of GRT" [29] and discusses the EHT collaboration measurements of M87* [1]-[6] and further observations.
The two main differences between classical GRT and LI of GRT are:

1.1 The philosophical difference

The spacetime philosophy of classical GRT differs from LI of GRT [30]. Some examples:
Time expands versus clocks run slower in gravitational fields,
space is curved versus measuring rods contract in gravitational fields,
space between galaxies expands and the galaxies are resting versus galaxies remove from each other with a certain velocity.
Everything that is falling into a black hole remains part of this world. There is no way into another universe. "How far can a dog run into the woods? Halfway, then it will be running out." Within classical GRT the dog will run into another universe.
"We have seen the gates of hell at the end of space and time," said astrophysicist Heino Falcke at a press conference in Brussels and he added: "What you're looking at is a ring of fire created by the deformation of space-time. Light goes around, and looks like a circle." [7]
Such fundamental differences in the philosophy of time and space should have observational consequences. As is shown this is the case for black holes.

1.2 The physical difference

Within LI of GRT there are no BH's but instead supermassive objects, SMO's, which own no event horizon. At the first sight this means a fundamental contradiction to GRT but this is not the case. SMO's are calculated [26] using the TOV equation which is pure classical GRT. All the other formulas of LI of GRT remain the same but they are interpreted in different ways with measurable consequences for BH's or SMO's instead [30], p. 312. As is shown below, e.g. there are conflicting spin measurements which are rational within LI of GRT.
Up to now (July 2020) there are six observations preferring LI of GRT and questioning classical GRT: EHT image of M87* ch. 2, Spin ch. 3, ALMA image of SGR A* ch.4, measurement of the period of the event horizon rotation ch. 5, conflicting measurements of the Hubble constant ch. 6, anisotropy of the universe ch. 7.
To get a first impression about the value of these arguments try fig.1 and fig.6.

Fig. 1 Sketches of a BH with accretion disk and a SMO in different directions

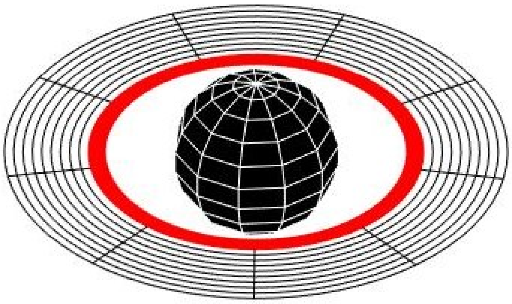

Abbildung 1 BH with accretion disk

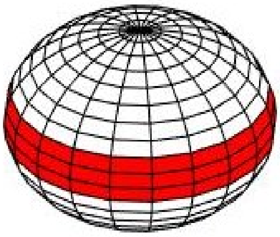

Abbildung 2 SMO with fire ring

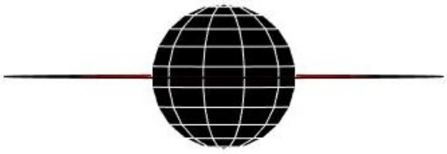

Abbildung 3 BH edge on

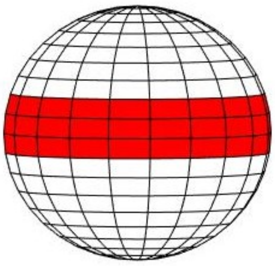

Abbildung 4 SMO edge on

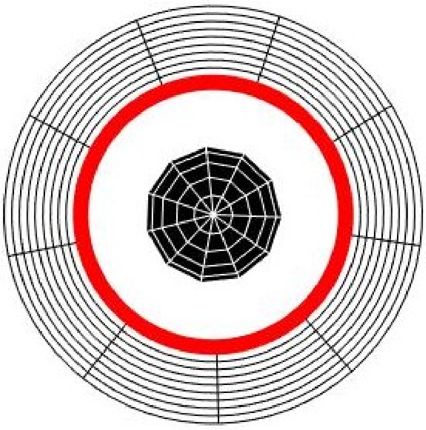

Abbildung 5 BH face on

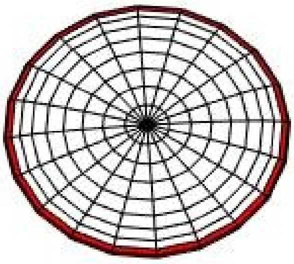

Abbildung 6 SMO face on

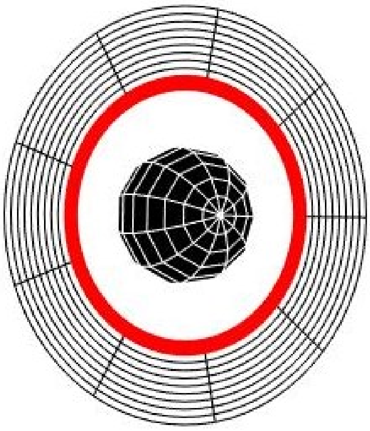

Abbildung 7 BH nearly face on

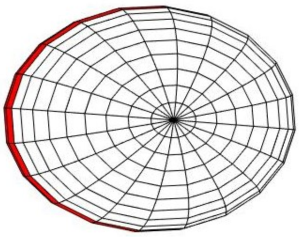

Abbildung 8 SMO nearly face on

Fig. 1. These sketches show some observable differences between BH’s and SMO’s. Looking edge on – Abbildung 3 and 4 – a BH is faint and a SMO bright. Looking face on – Abbildung 5 and 6 - there is ‘no’ difference between a BH or a SMO, you will see a ring in both cases but looking nearly face on – Abbildung 7 and 8 - a SMO has a bright edge and a accretion disk looks unchanged. This is important since this effect could correspond to the SEE region of fig. 2 in Ch. 2. (Doppler effects and gravitational lensing are not sketched. The heated regions are red.)

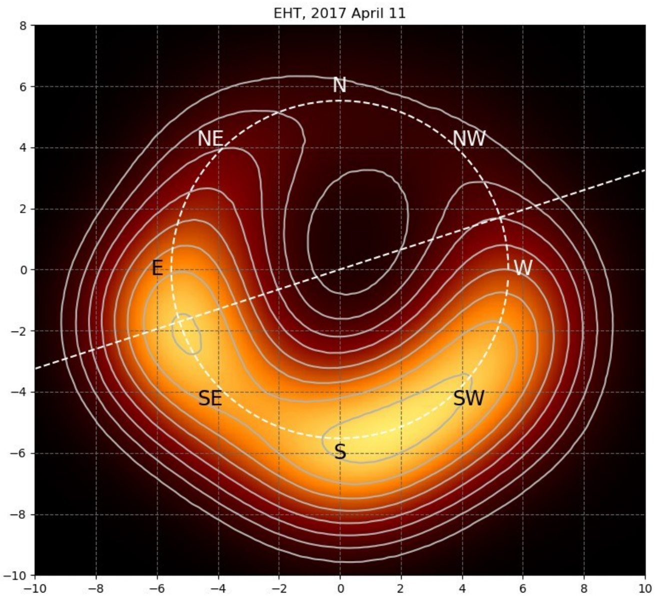

Fig. 2. Image of BH M87* at 1.3 mm wavelength obtained on April 11, 2017 by the Event Horizon Telescope (adapted from Fig. 3 in EHT Collaboration 2019a). The grey contour levels correspond to brightness temperature values. The white dashed lines indicate a photon ring of diameter 42 µas and the position angle of large-scale jet PA = 288◦ (NWW). The units of the grid are the angular size of the M87* gravitational radius θ_g = 3.8 µas. Taken from K. Nalewajko, M. Sikora and Agata Rózànskà [8]

2 Some open questions concerning the shadow of M87*

Updated 2020-03-08

BH's own an event horizon and SMO's not. BH's get their luminosity by friction of the plunging matter at the innermost edge of an accretion disk but SMO's get their luminosity mainly by accreting matter hitting the surface of SMO's and only partly by friction at the innermost edge of an accretion disk. The matter hitting the surface of SMO's is heated up and therefore it is called the fire ring of SMO's.
An exciting question concerning the shadow of M87*is discussed by K. Nalewajko, M. Sikora and Agata Rózànskà in 'On the orientation of the crescent image of M87*'[8]. They analyzed the crescent image of M87* with the result illustrated in Fig. 2. It shows how the spin or jet axis of M87* and the image of M87* of the EHT collaboration fit together. They state: "We strictly assume that (1) the BH spin vector is fixed to the jet axis, (2) the emitting regions are stationary and symmetric with respect to the BH spin, (3) the emissivities are isotropic in the local rest frames."[8] with the result: "Within the constraints of our model, **we have not found a viable explanation for the observed brightness of the SEE sector.** The SEE 'hotspot' might have been produced by a non-stationary localised perturbation in the inner accretion flow. Alternatively, it could result from locally anisotropic synchrotron emissivities."[8]

The brightness of the crescent image (region from W to SE in fig. 2) is explained by the Doppler effect of the approaching plasma but the bright SEE sector is already receding and should be darker. The authors suggest perturbation in the inner accretion flow or anisotropic synchrotron emissivity as a reason. This looks reasonable for classical GRT as well as LI of GRT. But LI of GRT allows another explanation, see fig. 1. Assume that the dashed photon ring in fig. 2 is the inner edge of the accretion disk of a black hole (Abbildung 1 of fig. 1) or part of the surface of a SMO (Abbildung 2 of fig. 1). (Doppler effects are not sketched). The SEE sector in Fig. 2 is the nearest part to the observer of the disk with the SEE sector being above the image plane and the NWW sector is fastest away being below the image plane. This is the situation sketched by Abbildung 7 for BH's and Abbildung 8 for SMO's. For BH's there is no difference between looking face on or looking nearly face on but for SMO's there is a difference. In Abbildung 8 you will see that the left side of the SMO is brighter as the right side and this agrees with the SEE section and the NWW section in fig.2. So, as demonstrated by Abbildung 7 and 8, one has a brightness effect seen only for SMO's.
The paper [8] points to an open question concerning the shadow of M87*, weather this proves the fire ring model of LI of GRT can be further investigated. In the EHT papers [1]-[6] it was claimed that the round shape of EHT image proves that there is a photon ring. Within LI of GRT there is the additional explanation that the accreted material hitting the surface of a SMO is heated up and a fire ring arises. Similarly, light flashes are the result of tidal forces disrupting a stellar object (classical GRT as well as LI of GRT) or the additional explanation for LI of GRT: a stellar object or even clumped material is hitting the surface of a SMO creating a light flash. Concerning the SEE sector of fig. 2 a further test of a fire ring would be an image of some BH which is seen edge on (Abbildung 3 and 4). This is done by the ALMA VLBI measurements of SGR A*, [27] and ch. 4 below. So, looking at SGR A* there should be a bright spot at the nearest part to the observer of the fire ring and not at the point of the fire ring with the highest approaching velocity. As far as discussed in [27] the image of SGR A* shows a bright region and no shadow in agreement with this prediction of LI of GRT. The up to now (March 2020) unpublished results of SGR A* of the EHT collaboration should do better because the EHT measurements make use of the ALMA telescope, too. So, the EHT image of SGR A* could become a deeper test of LI of GRT if these results were released.

3 Conflicting spin measurements of M87* and SGR A*

Newest spin measurements of M87* and SGR A* show values a*<= 1 but there are others with a* = 0.2 up to a* = 0.6. Within LI of GRT there are no BH's but SMO's having no event horizon. Therefore, following LI of GRT the luminosity of these SMO's results from accreting matter hitting the surface of SMO's and only partly by friction at the innermost edge of an accretion disk. The high values of a* arise because the bright equatorial region of the SMO's is interpreted by classical GRT as the inner edge of the accretion disk which by this is seen as very close to the photon sphere. The conflicting spin measurements are discussed. It is a continuation of chapters 7 and 8 of [29]. There are two groups, those near a*>≈ 0.9 and those with a* < 0.6. Both groups are using several different methods. It is shown that all a*≈ 0.9 measurements get a wrong, too high value if there is a fire ring as demanded by LI of GRT. The lower values of a* are measured with methods which are independent of a fire ring.

High a* values

High a* values were measured by observing x-ray flares, Reynolds [11] 2013 , Aschenbach et al [12] and others, by looking for the brightest point, Dokuchaev [13], and by investigating twisted light, Tamburini et al. [16], [17]. The observed a * values are a* > 0.9, a*= 0.9939 + 0.0026 − 0.0074, a* = 0.75, a* = 0.9 respectively.
Low a* values are measured by Dokuchaev et al. 2013 [14], Denis Nikolaevich Sob'yanin [18], Rodrigo Nemmen [19], Genzel, R. et al. [20], Nokhrina et al.[21]. The observed a* values are a* = 0.65±0.05, a* = 0.15±0.05 up to a* = 0.5±0.3, |a∗|≥ 0.4 in the prograde case and |a∗|≥ 0.5 in the retrograde case, and a* = 0.1−0.3 respectively.
The measurement methods of the high a* values rely on the fact, that a* is a function of the innermost stable circular orbit r_{isco} of Kerr BH's, s. fig. 3 of [29] and r_{isco} is determined by several methods which **don't take into consideration that there might be a fire ring** of LI of GRT. So, for x-ray flares [10] - [12] the highest measured redshift of the iron line is connected directly with r_{isco} but the highest measurable redshift of the iron line is emitted from iron ions of the fire ring, e. g. from the surface of the SMO. This is not taken into consideration. Some citations:
"Thus, the spin dependence of the ISCO directly translates into spin-dependent observables; as spin increases and the radius of the ISCO decreases, the disc becomes more efficient at extracting/radiating the gravitational binding energy of the accreting matter, the disc becomes hotter, temporal frequencies associated with the inner disc are increased, and the gravitational redshifts of the disc emission are increased." Page 3 and fig.1 of Reynolds 2013 [11].
"…we can determine the properties of the accretion disc itself (e.g., the ionization state of the surface layers and the elemental abundances of the disc) as well as the inclination of the disc and the location of the ISCO (hence the BH spin)." page 6 of [11]
"… **our method assumes that the accretion disc observables truncate at the ISCO; the spin constraint is almost entirely driven by this fact**." page 9 of [11].

The method of Dokuchaev et al. 2019 [13] to determine '*the brightest point in accretion*' is described by fig. 3. One can see immediately that a fire ring could change the position of the brightest point yielding a different r_{isco} and different spin. (But knowing the correct spin value then features of the fire ring can become determined with this method.)

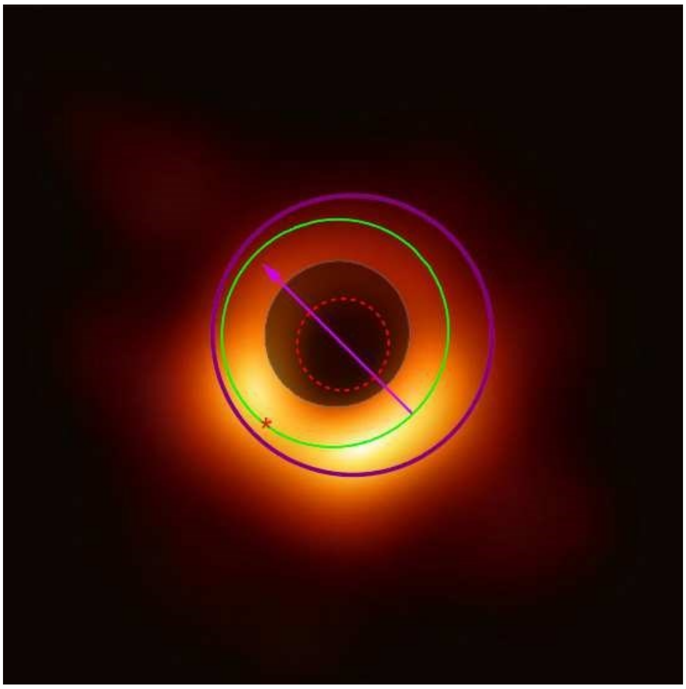

Fig. 3. Superposition of the M87* image, EHT [1–6], and the thin accretion disk model of [13] in the case of black hole spin a = 0.75. Star ⋆ marks the modelled position of the brightest point in the thin accretion disk at $r = r_{ISCO}$ (green ring). The closed dark red curve is a border of the black hole shadow. The dashed red circle is the observed position of the black hole event horizon in the imaginary Euclidian space. The magenta arrow is the black hole rotation axes. Taken from [13]

The high spin values with Tamburini et al.[16], [17] rely on the '*Measurement of the spin of the M87 black hole from its observed twisted light*'. Some citations:

“The twisted-light/OAM method, complementary to black-hole shadow circularity analysis, allows a direct probing of Kerr metrics and shows that the M87* rotates clockwise with an estimated rotation parameter a∼0.9±0.1.”
“Our simulations show that the main contribution to the phase difference comes **from the inner stable orbits that approach the Sgr A* event horizon**.”
This new and challenging method of Tamburini up to now leads to too high spin values if there is a fire ring. In this case the inner stable orbit appears to be at r_{smo}.

Low a* values

Low a* values were measured with methods independent of a fire ring. A first, very convincing one is presented by Dokuchaev et al. 2013 in ‘*Spin and mass of* Sgr A*’in fig.4. It is convincing because it consists of two independent measurements. *a** = 0.65±0.05.
Some citations:
“What is described below is the alternative QPO interpretation, related to the oscillation frequencies of the numerous hot spots in the accretion plasma [15,16,17,18,19,20], which are independent of the accretion model and defined completely by the properties of the black hole gravitational field.” Page 2 of [14].
“For this reason a moderate spin value of the supermassive black hole Sgr A* is quite natural due to specific conditions in the Galactic Center. Note also that the value of spin parameter a= 0.65±0.05, derived here by dint of QPOs, is in a qualitative agreement with the corresponding quite independent estimation, a≃0−0.6, from the millimeter VLBI observations of Sgr A* [49,50 Broderick].” Page 10 of [14].

Some further low a* measurements:

Denis Nikolaevich Sob’yanin (Денис Николаевич Собьянин) *Black hole spin from wobbling and rotation of the M87 jet and a sign of a magnetically arrested disc [18]*
a* = 0.15±0.05 up to a* = 0.5±0.3
“In the case of a test-particle precession, the specific angular momentum is J/Mc= (2.7±1.5) × 1014cm, implying moderate dimensionless spin parameters a= 0.5±0.3 and 0.31±0.17 for controversial gas-dynamic and stellar-dynamic blackhole masses. However, in the case of a solid-body-like precession, the spin parameter is much smaller for both masses, 0.15±0.05. Rejecting this value on the basis of other independent spin estimations requires the existence of a magnetically arrested disc in M87” page 1 of [18].

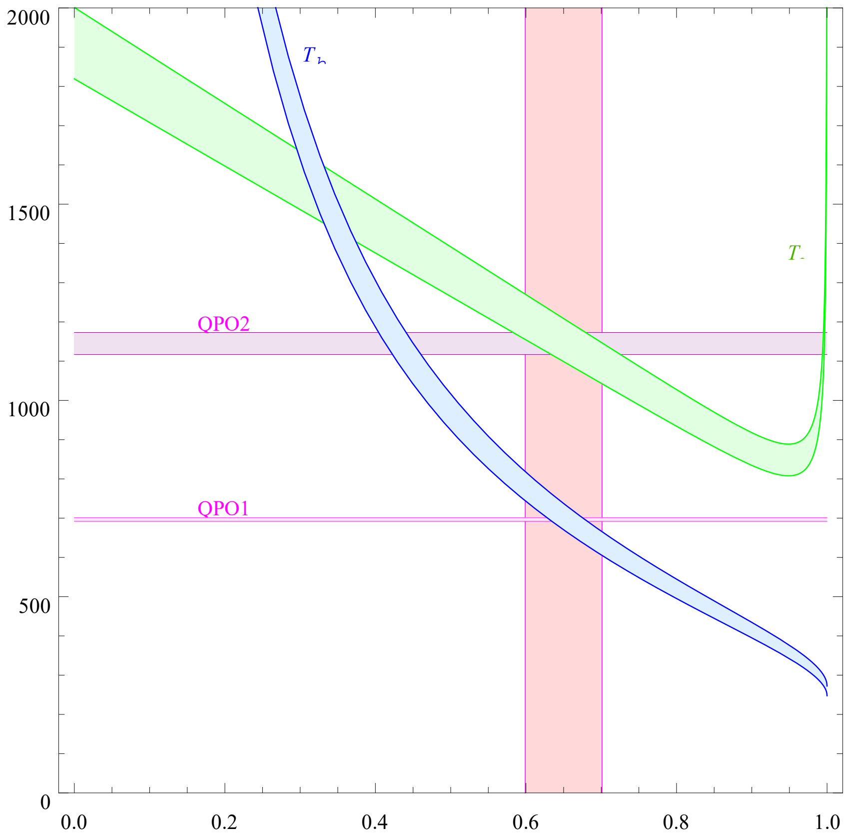

Fig. 4. *T(sec)* as a function of *a*. T_h and T_θ are blue and green respectively. “The observed QPOs with the mean periods 11.5 and 19 min (filled horizontal stripes QPO1 and QPO2) from the supermassive black hole Sgr A*, identified, respectively, with a period of the event horizon rotation T_h from (9) and a period of the latitudinal oscillation of the hot plasma clump at the near-circular orbit in the thin accretion disk with Ω_θ from (14). The filled region for T_θ corresponds to the numerically calculated permissible values of Q in (10) and (12), adjusted with the observational errors of QPO1 and QPO2 periods. The joint resolution of equations (9) and (14) with the observed values of QPO periods T_h and T_θ reveals the black hole spin, a = 0.65 ± 0.05 and mass, M = (4.2 ± 0.2)$10^6 M_\odot$, shown in Fig 7.” Taken from [14].

Rodrigo Nemmen *The Spin of M87* [19]*
|a∗|≥ 0.4 in the prograde case and |a∗|≥ 0.5 in the retrograde case.
"We find a lower limit on M87*'s spin and magnetic flux of |a∗|≥ 0.4 … in the prograde case, and |a∗|≥ 0.5 … in the retrograde case, otherwise the black hole is not able to provide enough energy to power the observed jet. These results indicate that M87* has a moderate spin at minimum …" [19]

Genzel, R. et al. [20]
Sgr A* a* = 0.52
"Two flares exhibit a 17-minute quasi-periodic variability. If the periodicity arises from relativistic modulation of orbiting gas, the emission must come from just outside the event horizon, and the black hole must be rotating at about half of the maximum possible rate." [20]

Nokhrina et al. *M87 black hole mass and spin estimate through the position of the jet boundary shape break [21]*
"Thus, we have obtained the moderate spin parameter of the order of 0.1−0.3 for M87 SMBH." [21]

Conclusion
Do we have an experimental proof of LI of GRT? Yes, perform a measurement of the Spin of M87* using a method not influenced by a fire ring and using another one which is influenced by a fire ring. If the measurement results agree, then there is no fire ring. The above discussed spin measurements prove the contrary.

4 ALMA and EHT measurements of SGR A*

A note added to the ALMA discussion which prove LI of GRT in [27], page 1. S. Issaoun and H. Falcke stated: "the radio jet is pointing almost at us" and we are looking at a bright emission center hiding the shadow. Following HAWTHORN et al [31], and their fig. 1 and 2, such a spin direction does not fit with observation.
The EHT measurements of SGR A* though made together with those of M 87* are not publicized up to now (March 2020). What is the reason? Making a guess, there is no difference to the ALMA results and no shadow of a BH is seen. No shadow and therefore no publication? But there is an argument of H. Falcke in the contribution Why didn't the Event Horizon Telescope team mention Sagittarius A*? [32]: It is "hard to photograph. It was easiest to take a picture of M87." "It is very difficult to photograph the black hole in our Milky Way, because the material around it moves very fast: the vortex rotates around its axis in 20 minutes. Compare it to a toddler who has to sit still for hours to be photographed: that's not possible. With M87, the matter revolves around the hole in two days, so it's easier to photograph". The counterargument: The shadow of a BH has no frequency of 20 minutes or two days but should be seen all the time. So, what is the result of the EHT measurements of SGR A*? The arousing suspicion is that the results might not fit with the predictions and therefore are being hold back. (Excuse, my guess from March 2020 is not valid. J. Brandes 1.6.2022))

5 Measurement of the period of the event horizon rotation

A further consequence from Fig.4. QPO1 is the measurement of the period of the event horizon rotation T_{h}. Within LI of GRT T_h is the period of a SMO and such a period should be measurable. But within classical GRT the period of a BH is measured by signals from rotating objects near the event horizon and these signals have an infinite redshift, die away and are not measurable. If this argument is in order then the measurement of T_h alone proves LI of GRT.

6 Conflicting measurements of the Hubble parameter

There are two different measurement results of the Hubble parameter, see e. g. [33]: "The new estimate of the Hubble parameter is 74.03 kilometres per second per megaparsec. The number indicates that the Universe is expanding at a rate about 9 percent faster than that implied by Planck's observations of the early Universe, which give a value for the Hubble parameter of 67.4 kilometres per second per megaparsec."
This contradicts the idea of an expanding universal spacetime since two different Hubble parameters

$$H(t) = a'(t) / a(t)$$

means two different scale factors *a(t)* and/or *a'(t)* and therefore two different expansion rates of the universe at the same time as well as two different redshifts for the same galaxy e.g. relative to us. Observable is always one value only. Within LI of GRT the expanding universe is described by an expanding dust star using similar formulas as classical GRT for the expanding universe [30, ch.19 and 22]. In this case different Hubble parameters in different regions of the universe are not a fundamental problem since a dust star is only a rational approximation to exploding matter. Similar, a directional dependence of the Hubble parameter would be no problem, too. For LI of GRT another problem might arise: At Big Bang the universe is extremely dense and it should become a BH at once. But then it could not expand like a dust star. Fortunately, this is no severe problem: LI of GRT postulates SMO's instead of BH's. At Big Bang there is a SMO and no BH. Classical GRT has no difficulty with BH's at Big Bang since the expansion of spacetime means resting galaxies and that is different from the expansion of a dust star with moving dust particles resp. galaxies. In the later case classical GRT gets a BH and a Big Bang could not occur.
So, there is the thesis: Two different estimates of the Hubble parameter refute the idea of 'expansion of spacetime' and prove LI of GRT … **and as a logical consequence refute BH's**.
To get rid of this problem classical GRT must eliminate one of the Hubble parameters. The latest help are the ideas of Maria Bergemann et al. discussed in [34]. Possibly, supernovae 1a are no longer suitable standard candles. The Hubble parameter of 74.03 kilometres per second per megaparsec could become obsolete. But further considerations are necessary.
Some arguments why this wouldn't help: Measurement of the Hubble parameter using gravitational lensing leads to high values near the above 74.03. Gravitational lensing observes supernova 1a as well but makes no use of them being standard candles. [35], [36]. So, the objections of [34] are not applicable. The next problem for classical GRT are the measurements using red giants [37], [38].

A further result: direction dependent Hubble parameters H_0 – 3.7.2020

In Mighas et al. [39] "*Probing cosmic isotropy with a new X-ray galaxy cluster sample …*" the authors prove a direction dependent Hubble parameter $\boldsymbol{H_0}$, see fig.5. For ~300 x-ray galaxy clusters the luminosity L_x, the inter-cluster mass temperature T and the redshift z became measured. Together with their relation to the luminosity distance D_L the corresponding $\boldsymbol{H_0}$ was calculated. The direction dependent values of $\boldsymbol{H_0}$ are seen in fig.5.

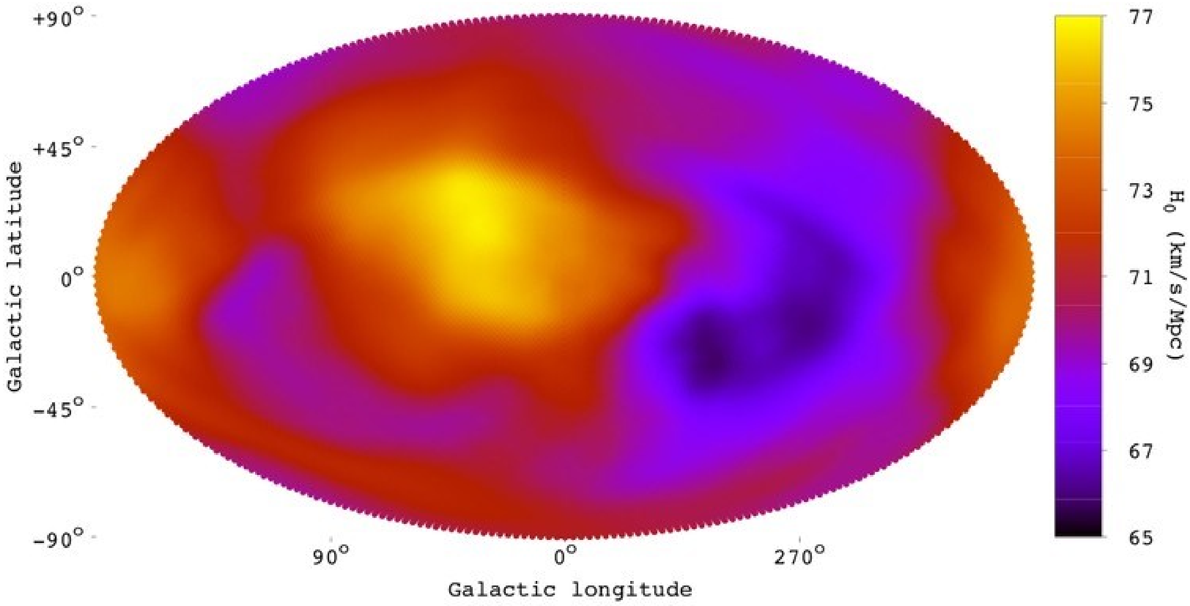

Fig. 5: Best-fit $\boldsymbol{H_0}$ value as a function of the position in the extragalactic sky. Taken from [39], [40]

7 The anisotropy of the universe

In the following some observations of an anisotropic universe are discussed. Longo [41]: “Assuming that the universe is isotropic, it is expected that in a sufficiently large sector of the universe the number of galaxies that rotate clockwise will be roughly equal to the number of galaxies that rotate counterclockwise. However, recent evidence suggests that the local universe does not follow that expected balance, and show that the ratio between clockwise and counterclockwise galaxies in some regions is significantly different than 1:1, introducing galaxy handedness asymmetry.”
This is illustrated by fig. 6.

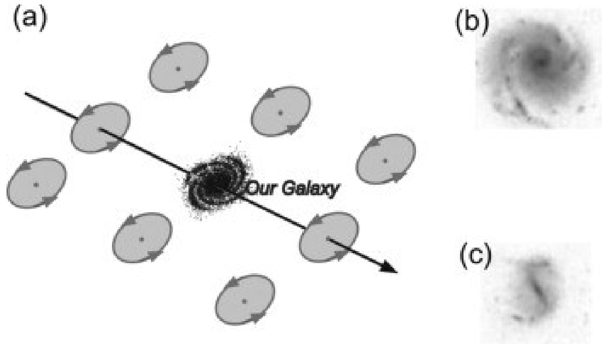

Fig 6 (a) A hypothetical universe with all galaxies having the same handedness. Note that galaxies in one hemisphere would appear to us to be right-handed and in the opposite hemisphere left-handed. (b) A "typical" spiral galaxy from the dataset of SDSS galaxies. This one is defined as having right-handed "spin". (c) A left-handed two-armed spiral galaxy. Taken from [41]

Concerning the dataset of Sloan Digital Sky Survey (SDSS) galaxies Longo [41] stated: “**This sample included 25612 galaxies and gave right handed spin R=12707, left handed spin L=12905 and an overall asymmetry (R-L)/ (R+L) of –0.0077 ± 0.0062**”. Shamir [42] improved this observation: “Annotating the dataset of SDSS galaxies by their spin direction provided a dataset **of 88,273 galaxies with clock-wise spin patterns and 86,075 galaxies with counterclockwise patterns**.” This results in **an overall asymmetry (R-L)/ (R+L) of -0.0126 ± 0.0024.** So, one has **two independent investigations with an anisotropy of 0,77 and 1,2 %.** “According to these observations, the local universe is not isotropic, meaning that the observed physical characteristics of the universe are different in different directions of observation” Shamir [42]
Further anisotropies are observed for radio sources, short gamma ray bursts, luminosity-temperature ratio of 313 galaxy clusters [39], as discussed before, and Cosmic Microwave Background (CMB) data also shows evidence of possible cosmological-scale polarization. Details see Shamir [42]. “Since the spin patterns of a galaxy as visible from Earth is also an indication of the actual spin direction of the galaxy, **the large-scale patterns in the distribution of the spin directions can be an indication of a rotating universe** ”, Shamir [42].
Three descriptive links concerning anisotropy of the universe (in German) see [47] – [49]:
In Wikipedia Germany there is some comment defending isotropy, [50]: „Bei ersten Analysen der Himmelsdurchmusterung Sloan Digital Sky Survey kam die Theorie auf, dass sich Spiralgalaxien bevorzugt in eine Richtung drehen. Um dies zu bestätigen oder zu widerlegen wurde das Online-Projekt Galaxy Zoo ins Leben gerufen, bei dem tausende Amateure Galaxienbilder nach deren Drehrichtung bewerteten. Eine bevorzugte Drehrichtung stellte sich hierbei jedoch nicht heraus, [46]“.
The counterarguments by Shamir [44]: “Another attempt was made by using crowdsourcing analysis of SDSS galaxies (Land et al., 2008, [46]), which also showed no statistically significant difference between clockwise and counterclockwise galaxies. However, that study also showed that untrained volunteers do not excel in the task of classifying galaxies by their spin patterns, leading to an unclean dataset, heavily biased by the human perception (Land et al., 2008, [46]). When comparing the photometry of just the annotations on which 95% or more of the volunteers agreed on, the photometric differences between clockwise and counterclockwise galaxies was aligned with the same photometric asymmetry observed in (Shamir, 2017c, [45]), but the selection of the galaxies makes the dataset too small to be considered statistically significance (Shamir, 2017b).” and Shamir [45]: “It should be noted that the number of Galaxy Zoo galaxies with “superclean” annotations is much lower than the number of galaxies in the other datasets, and therefore statistically significant difference is not expected. The same RA range in the opposite hemisphere had a much lower number of just 687 galaxies with “superclean” agreement between the voters, and the low number does not allow a meaningful analysis.
Let us assume that these observations prove an inhomogeneous and anisotropic universe then this prefers LI of GRT as well and **following the arguments of ch. 6 one has as a logical consequence the refutation of BH’s**

Similar to spin anisotropy there are measurements proving position and time dependent density values of cosmic matter not explainable by standard cosmology, e.g. Hendrik Hildebrandt et al. [51], [52]. An explanation given by Hendrik Hildebrandt needs concepts of dark energy. Perhaps LI of GRT might be helpful [53] but there is no straight connection with LI of BH’s.

8 Genzel questions first image of BH

This image everyone will remember:

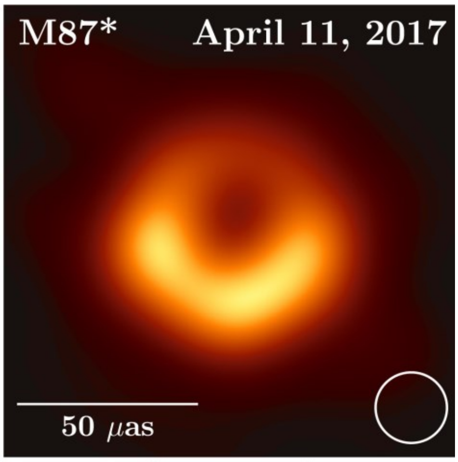

Fig 7 First image of a black hole

It is claimed as the first image of a black hole as well as the absolute proof that there are black holes. This is now questioned openly by Nobel prize winner Reinhard Genzel. Thereto I cite from a discussion within the German newspaper “Der Spiegel” [54]:
Spiegel: „Wo immer über schwarze Löcher berichtet wird, sieht man dieses Bild [Fig. 7]. Und Sie sagen uns jetzt, dass wir gar nicht wissen, was es eigentlich zeigt?“
Genzel: „So ist es. Es kann sein, dass wir den Schatten des schwarzen Lochs sehen, so wie es gemeinhin dargestellt wird. Aber es könnte auch sein, dass es sich um die Außenwand eines Jets handelt, der sich mit Lichtgeschwindigkeit direkt auf uns zukommt. …“
Translated:
Spiegel: „Wherever it is reported on black holes you will see this picture [Fig. 7]. And now you tell us that we don’t know what it really shows?”
Genzel: “So it is. It is possible, that we see the shadow of the black hole as it is commonly presented. But also, it could represent the outside of a jet approaching us with the velocity of light. ...”

Some simple consequences: LI of GRT is not rejected up to now - possibly there are no black holes. Classical GRT should tolerate this fact till there are better observations.
Genzel’s explanation of the image [Fig. 7] as the outside of a jet fits quite well with LI of GRT. The fire ring of LI of GRT might be the starting region of the jet and counter jet, part of the infalling matter quite naturally might drift towards the poles and there becoming accelerated by rotating magnetic fields and reconnection processes. The rotating fire ring together with the rotating SMO are the source of the angular momentum of the jets. The surface of the SMO quite naturally drives the infalling matter to the poles.
Now, classical GRT could agree with Genzel’s alternative explanation of the image [Fig. 7] since two further EHT-papers [57], [58] prove poloidal magnet fields of about 1 - 30 G. “The presence of such magnetic fields in a rotating fluid would imply that the magnetic fields are dynamically important.” [58] and this could explain how jets arise near the event horizon. But the arguments of Genzel remain valid. It is not clear what we really *see* - the accretion disk or parts of the jet.

Genzel’s revision see chapter 13.

9 SMO’s become more turbulent

SMO’s become more turbulent. This makes “fire rings” of LI of GRT more plausible.
These ideas follow from M. Wielgus et al. [55] and the Science News article [56]. The main result is illustrated by fig. 8.

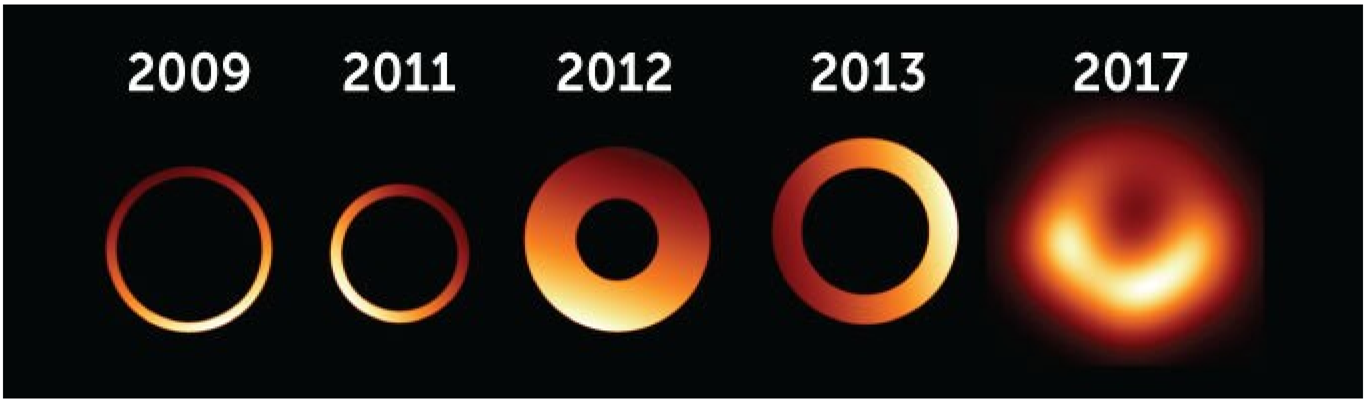

Fig. 8. Preliminary Event Horizon Telescope data reveal how the brightest spot on the ring of light around M87’s black hole shifts over time. Researchers compared the real image (far right), created from observations taken in 2017, with simulations of what the black hole looked like earlier based on preliminary data from 2009 to 2013. The changes are due to turbulence in the tempest of material swirling into the black hole. M. Wielgus, D. Pesce [55]. Taken from [56].

This means by classical GRT: “The ring’s uneven glimmer arises from the tumultuous flow of superhot plasma around the black hole”, [56].
The quite natural interpretation by LI of GRT: The ring’s uneven glimmer arises when lumped material hits the surface of the SMO.
A possible, important consequence: The brightness of the southern region of the famous 2017 picture of M87* has the same reason and is not a Doppler effect caused by fast rotation. If no Doppler effect or only a small one is observed by further measuring then the spin of M87* is low. The consequences of a low spin: see chapter 3 above.
There should be further observable differences between uneven glimmer caused by wobbling of plasma or caused by accreting matter hitting the surface of a SMO.

10 The 'boundary layer' of accreting NS's favoring LI of GRT

Introduction: observation of the 6.4 keV iron line

Within LI of GRT low or super massive BH's and NS's are similar objects since they are degenerated objects [26] with high mass densities. Therefore, it is quite natural to extent the theory of NS events to similar ones of BH's. One example are flare events. They originate from NS's as well as near from BH's and have similar features but their theory is different on account of the event horizon of BH's. Within LI of GRT SMO's are heated up locally by infalling matter and by this could emit flares similar to NS's. Within classical GRT flares of BH's are TDE's (tidal disruption events) or are emitted from the accretion disk. This difference is observable in principal.

A nice example for different theories of the same event is seen in fig. 9.

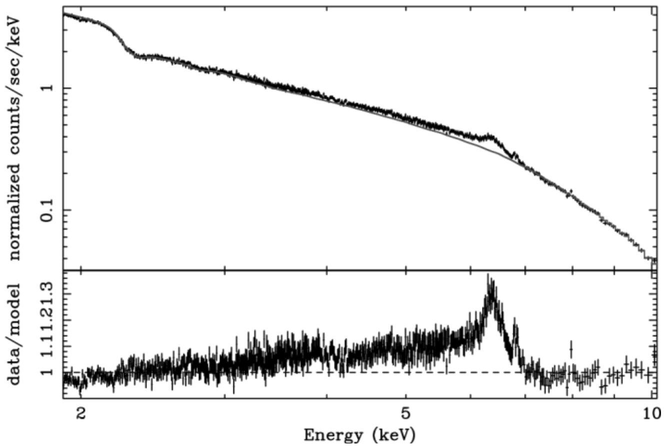

Fig. 9. The top panel shows the 2 – 10 keV Spectrum of AGN MCG-6-30-15 fitted with a power law.
The bottom panel shows the profile of the 6.4 keV iron line, expressed as the difference between the observed spectrum and the power law model. It is dilated down to 3.5 - 4.2 keV. This figure is taken from Brenneman and Reynolds [60] and Kolb [59]

The event is the 6.4 keV iron line in the energy spectrum of the supermassive object AGN MCG-6-30-15. The 6.4 keV iron line is delated by gravitational redshift down to 3.5 - 4.2 keV and the question: what is the reason for the time dilation? There are two possibilities.
1.) classical GRT. The most dilated iron ions are part of the inner edge of the accretion disk because this is the nearest stable position near the event horizon..
2.) LI of GRT. The most dilated iron ions are resting on the surface of the SMO.
Let us calculate the radial position (radius *r*) of the dilated iron ions in the gravitational field. From the Schwarzschild metric one gets the formula for gravitational redshift [e. g. Talk-Brandes-2013]

$$\tau = t\left(1-\frac{2GM}{c^2 r}\right)^{1/2}$$

and from this the measured frequencies

$$\nu_{\tau,measured} = \nu_t\left(1-\frac{2GM}{c^2 r}\right)^{-1/2}$$

or with $\mathrm{E} = \mathrm{h}\nu$ the energy relation

$$\mathrm{E_{Fe}} = \mathrm{E_{Fe0}}\left(1-\frac{2\mathrm{GM}}{\mathrm{c}^2 \mathrm{r_{Fe}}}\right)^{-1/2}$$

Using

$$\mathrm{E_{Fe0}} = 6.4\mathrm{keV}$$

$$\mathrm{E_{Fe}} = 3.5\ \mathrm{keV}\ -\ 4.2\ \mathrm{keV}$$

One gets

$$\mathrm{r_{Fe}} = 1.4\mathrm{r_{SM}} - 1.8\mathrm{r_{SM}}$$

(Time dilation by velocity is neglected.)

This result is rational for both cases. If one assumes a high rotating black hole (Kerr metric, $a^* \approx 1$) then the innermost stable orbit r_{ISCO} reaches $r_{ISCO} = 1.5\, r_{SM}$. In the case 2.) the TOV calculations of SMO's [26] result in $r_{SMO} = 1.54 r_{SM}$. The open question: Who is right? A low spin a^* prefers LI of GRT: see chapter 3 above.
In the following we discuss observations favoring LI of GRT.

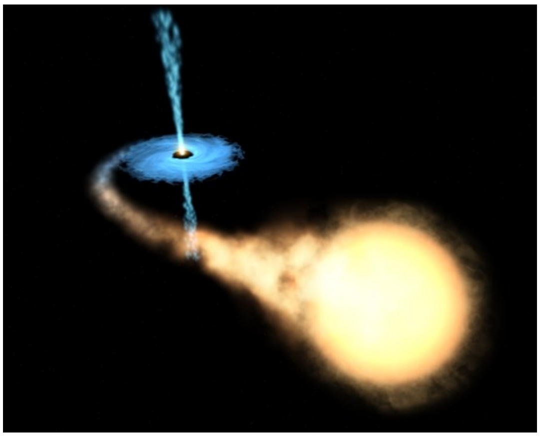

Fig. 10 Binary system. Accretion onto a BH from a star (yellow).
The accretion disc (blue) is painted in its efficient state (high mass accretion). With less mass accretion the radiation power gets fainter. Finely no disc is built up and the matter is falling into the BH without radiation. If there is a NS one could see radiation from its surface. Taken from [61]

The main argument favoring LI of GRT – observations of Cen X-4

Let us start with some elementary considerations. Consider a NS and a small mass BH. Let some matter falling down radially in their gravitational fields. In the case of a NS you get a light signal when the matter hits the surface of the NS e.g. produced by bremsstrahlung. In the case of a BH you will see nothing, all the matter is absorbed without radiation. In the far distance there is no observational difference between both effects. Now you can increase the infalling matter repeatedly with the same null result. Going on, not only the NS but the BH also become observable. The usual explanation: The infalling and rotating matter settles into an accretion disc, s. fig. 10. With low mass rates you get a state called 'radiatively inefficient flow' (RIAF) with low radiation and with high mass rates you get the 'efficient state' with bright radiation. The radiation energy is accretion energy transformed by friction within the disc. Now, better observations challenge the explanation of the RIAF state. In [62] – [65] by observations of the binary Cen X-4 it is proven that in the case of NS's the RIAF state means radiation from the NS surface and not from the disc. A disc is necessary no longer and this questions the RIAF state of BH's. In the following this is discussed in more detail and as far as these considerations are convincing the *nearby* question arises: Why does a BH radiate in its RIAF state similarly as a NS though a BH has no surface? And the *nearby* answer: BH's own a surface and no event horizon.

In the rest of this chapter the new theory of 'radiatively inefficient accretion flow' (RIAF), [62] – [65], is explained for NS's and then for BH's.

The 'boundary layer' of an accreting NS demonstrated for Cen X-4

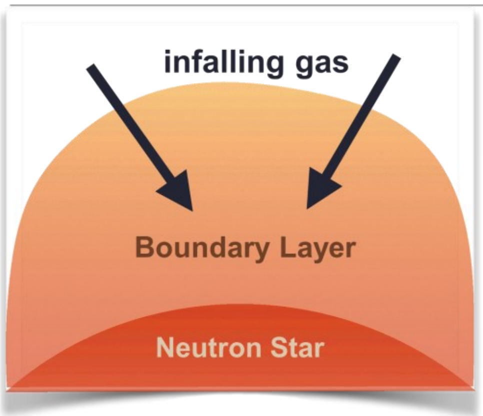

Fig. 11 Boundary layer. Infalling matter before being accreted by the NS spreads across its surface and a boundary layer arises. Since the infalling matter has a varying angular momentum the boundary layer differentially rotates relative to the NS. In fig. 1, the boundary layer is called fire-ring. Sketch taken from [62].

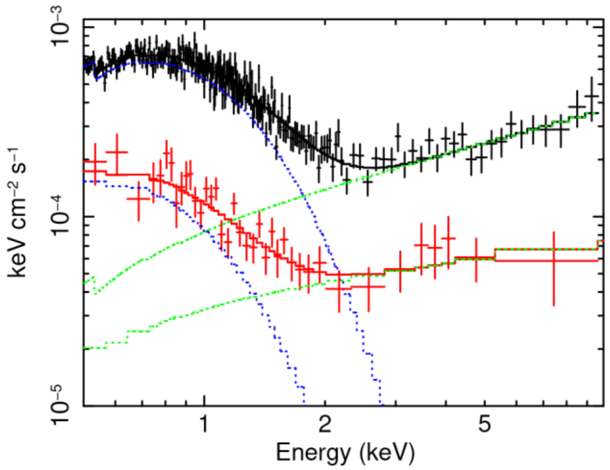

Fig. 12 Unfolded spectra from the brightest (black) and faintest (red) quiescent observations of Cen X-4. The neutron star atmosphere (blue, dashed line) and power-law (green, dotted line) components are also shown. The ratio of the thermal and the power-law components remains the same though the spectra show a fast and large variability of brightness. Taken from Cackett et al. [64].

Fig. 11 illustrates well what a boundary layer means. It is the bulk of matter falling onto the surface of the NS before being accreted finally. But what is its physical importance? It is the place where the observed spectra, fig. 12, during the 'radiatively inefficient accretion flow' (RIAF) are produced. This is no longer the accretion disc. Typically, the spectra consist of a thermal component from the neutron star atmosphere (surface) and a power-law component which is optically thin thermal bremsstrahlung arising in the boundary layer. "One striking finding is that while the total luminosity varies by a factor of over 4 the ratio of thermal to power-law flux remains approximately constant [Fig. 12]. This appears to indicate that the thermal and power-law components are linked together, thus …", [Cackett] This finding is really important since it proves that both components arise at the same place. Especially the power-law comes from the boundary layer and not from a disc corona. For BH's having an event horizon and no surface these considerations are not valid. "In this paper [Angelo], we propose that the power-law component seen in Cen X-4 and similar quiescent neutron star binaries is most plausibly produced by bremsstrahlung emission from the boundary layer on the surface of the star. This suggests that *all* the observed emission is coming from near the surface of the star, and the power-law and thermal components are directly coupled." See fig. 12.
Some additional citations from [Angelo, 63] and [Chakrabarty, 65] might be helpful:
"We then demonstrate that the most plausible model for the power-law component is bremsstrahlung from the star's surface."
"As mentioned above, the 0.5–10 keV spectrum shows two components – a soft blackbody-like component and a harder component well fitted by a power law with photon index $\Gamma \sim 1$–2 – which vary together and contribute roughly equal amounts of flux (Cackett et al. 2010, 2013; Bernardini et al. 2013)."
"As we show below, the low-energy spectral cut-off and hard spectral index clearly suggest bremsstrahlung emission (as previously concluded by Chakrabarty et al. 2014), while the near-balance between the thermal and power law components strongly suggests the power law is emitted from the boundary layer of the star, rather than in the accretion flow."
"The most plausible radiation mechanism to explain the power-law spectrum is optically thin thermal bremsstrahlung."
"It also offers a reasonable explanation for the energy balance between the bremsstrahlung and blackbody components."
"The quiescent X-ray spectrum of Cen X-4 is most likely produced by the final fall of accreting matter on to the surface of the neutron star."
"In this paper we have argued that the quiescent emission from the neutron star Cen X-4 originates predominantly from the impact of the accretion flow on to the surface of the star (most likely without strong modulation by the magnetic field), without an equivalent contribution from the accretion flow."
"Since the present observation of Cen X-4 shows both a thermal and power-law component from the surface of the star."
"As we argue in this paper, the power-law component in all quiescent neutron stars is most likely generated very close to the surface of the star, and this accretion on to the surface could result in enhanced quasi-blackbody emission."
"We conclude that bremsstrahlung emission from the RIAF flow is consistent with our observed spectral cutoff and luminosity, but placing this emission far from the NS is difficult to reconcile with the fact that the soft and hard emission vary together on short timescales." [Chakrabarty, 65]

With other words: Radiatively inefficient accretion flow (RIAF) of all accreting NS's consists of spectra similar with fig.12. Its origin is a boundary layer as it is sketched in fig. 11. The RIAF spectra of a BH's are similar but not explainable in the same way on account of BH's having an event horizon and no surface. In the next step we leave this assumption.

The 'boundary layer' of an accreting BH

Concerning a boundary layer and a surface of BH, the very convincing way to prove their existence are luminosity measurements of BH's yielding the same spectra as in fig.12. Up to now those observations are missing because the binary Cen X-4 is an exception being very close to us. What remains is the spectral similarity of BH's and NS's when they are classified as being in a state with a

radiatively inefficient accretion flow (RIAF). In this situation "… power-law emission is typically seen in the accretion flow of both black hole and neutron star binaries at low luminosities." It is seen that "… accreting black hole and neutron star accreting systems spend the vast majority of the time in this low-luminosity state," and "Neutron stars in accreting binary systems show similar spectral and variability properties to those of black hole binaries (suggesting similar accretion physics) ..." [Angelo]
There was some theoretic effort to give another explanation using disc properties instead of a surface but it failed: "In black holes at somewhat higher accretion rates, it has been suggested that the hard X-ray emission comes from an optically thin corona overlying a cold, optically thick disc, although in this case the underlying disc is heated and should produce comparable luminosity to the corona (Haardt & Maraschi 1991) and a strong Fe K emission line (e.g. Ross & Fabian 1993), neither of which are observed." **So, introducing a boundary layer and a surface for BH's is more reasonable**. A further step are observations of differences in the surface of NS's and BH's. The surface of NS's might be harder. Further proof may arise from the theory of jets, flares and TDE's (tidal disruption events).

The main result: Weak accretion onto NS's and BH's needs no discs since there is no difference to free falling particles. Angelo et al. [63] have proven that radiatively inefficient accretion flow (RIAF) of NS's really means the same: disc features are unimportant. The observed spectra are nicely explained by the features of a boundary layer and of a surface. The next step is nearby. Instead of being dark, BH's radiate with similar spectra as NS's. So, BH's own a boundary layer and a surface as well.

11 EHT image of Sgr A* from 12.5.2022 and LI of GRT - part I

Fig. 13 is the awaited eagerly image of Sgr A*. It is a convincing result since it is a face-on image of Sgr A* which looks very similar to the face-on image of M87*, fig. 7. “The lower mass and, hence, shorter dynamical scale of Sgr A* introduced significant complexity to the imaging.” [77] Having overcome these difficulties is a great step forward in astronomical observation. The next great and advisable step is the Earth-orbiting satellite telescope. Chapter 4 of EHT VI [72] is a helpful start for discussing LI of GRT.

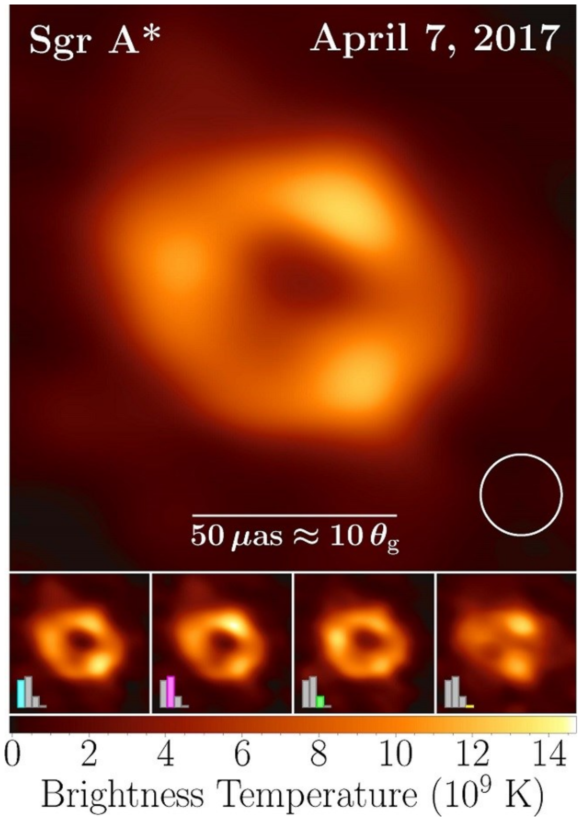

Fig. 13 EHT image of Sgr A*. Top: Ring-like images dominate the wide range of images obtained across multiple methods, however, variability and sparse visibility domain coverage make selection of a single image impossible. The inset images represent different imaging solutions and their associated frequency (histograms). Taken from: “Focus on First Sgr A* Results from the Event Horizon Telescope” by Geoffrey C. Bower [77].

Following the mainstream, the author expected that the image of Sgr A* would be edge-on. Now there are two face-on images and therefore this is no real new perspective but very helpful too. The main aim of EHT observations is to prove the photon ring of fig. 14. Fig. 15 explains how a photon ring develops. The counterargument by LI of GRT is as follows: There is a (degenerated) SMO with a boundary layer and a radius of some r_{SM} . Possibly the radius of the SMO is large enough to prevent an image of the photon ring or at least distorts it.
In other words: If one observes a ‘photon ring’, one doesn’t know whether it comes from the inner edge of an accretion disk or from the boundary layer of a SMO. Perhaps both possibilities have observable differences.

Following fig. 11 you can interpret fig. 15 differently and take the accretion disk in fig. 15 as the boundary layer of a SMO and r_e as the radius of the SMO sphere. Its interior is filled with matter (and this part of fig.15 should be gray scaled without a black shadow). The question: Are there are observable differences between both versions? Perhaps the photon ring becomes distorted by the SMO sphere?

As mentioned earlier, the following argument is in favor of SMO’s: The ring in Fig. 7 and 13 is the image of the boundary layer of a SMO. By classical GRT it is interpreted as ISCO of a BH with high a* (Kerr BH). Hence, an independent measurement of a* is highly desired. a* could become low, see chapter 3.
.

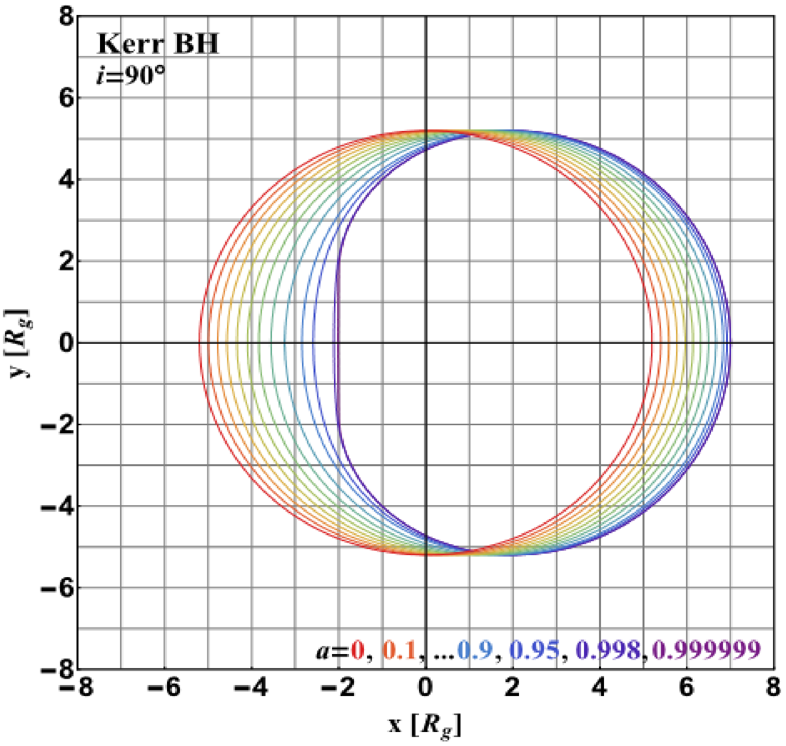

Fig. 14. BH shadow boundary curves. Kerr BH with varying spin parameter. The inclination angle (i) is fixed as 90°. Taken from [78]

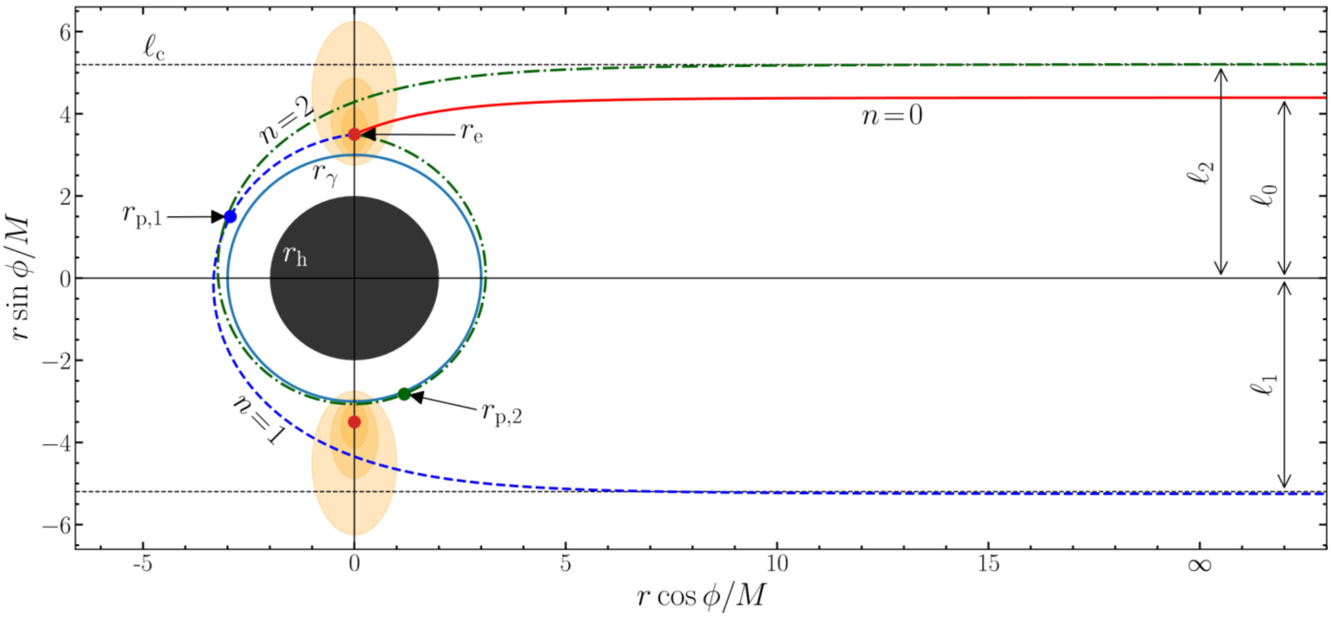

Fig. 15. A simple model of the emission around a spherically symmetric static black hole. The observer is located to the right, at $r \to \infty$, viewing the accretion disk face-on. Black hole has a horizon radius r_h, there is a photon sphere located at r_γ (blue circle). The emission from the accretion disk (represented with orange ellipses) is dominated by the flux emitted at the effective radius r_e. The photons emitted at r_e may reach the observer along infinite number of trajectories, corresponding to adding half loops around the photon sphere. First 3 such trajectories are shown. They correspond to the direct image (n =0), and first and second photon ring (n =1 and n =2). Radii of n-th photon rings in the observer's plane converge rapidly to the critical impact parameter, $l_n \to l_c$ which defines the critical curve on the observer's screen. Taken from Wielgus [79].

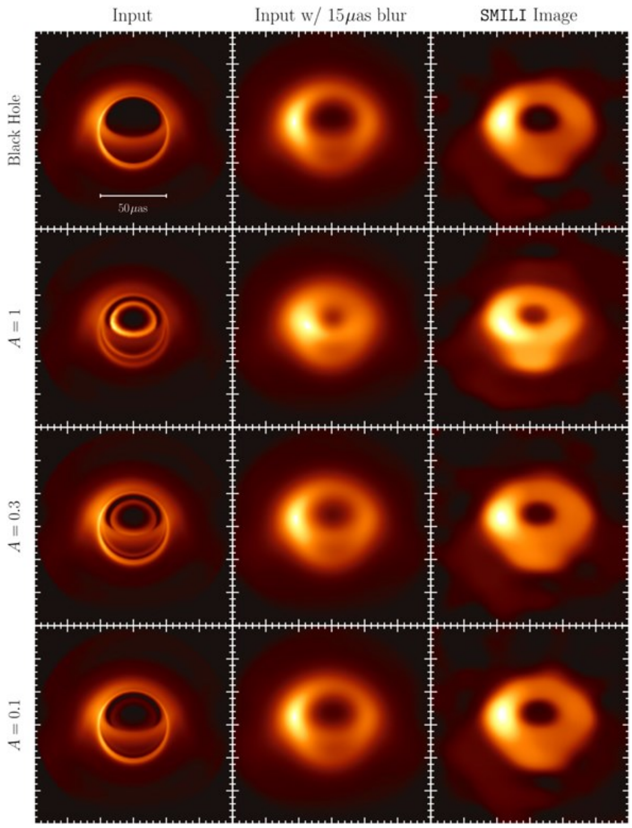

Fig. 16
"Comparison of a synthetic image of a hot accretion flow around a black hole with corresponding images when the central object has a reflecting surface. … **Third row**: similar to the second row, but for albedo A = 0.3. Compared to the A = 1 model, in this case the difference from the black hole image due to the presence of a surface is only marginally detectable. **Bottom row**: model with surface albedo A = 0.1. Here the image is indistinguishable from the black hole image (top row) at the resolution and sensitivity of the EHT 2017 data."
Taken from EHT-group [72, fig. 15]

There are two arguments from EHT VI [72] which are helpful for LI of GRT

1.) "While there is overwhelming evidence that Sgr A* contains a large amount of mass confined within a very small volume, the question of whether it is a true black hole remains unresolved." [72, page 11]
2.) "In the case of the A = 0.3 model, and especially the A = 0.1 model, the SMILI reconstructions do not differ much from the black hole image; hence, it would be hard to distinguish such models using the current EHT data." [72, page 18]. This is explained in fig. 16.

Though it is experimentally an open question whether there are SMO's and no event horizon, the authors of VI [72] are convinced that theoretical considerations alone are able to refute the alternatives of fig. 16 even in the case A=0.3 and A=0.1.
This are the theoretical arguments, mainly by Broderick et al.:

1.) "To consider alternatives to the presence of an event horizon, we explore the possibility that Sgr A* is a compact object with a surface that either absorbs and thermally reemits incident radiation or partially reflects it. Using the observed image size and the broadband spectrum of Sgr A*, we conclude that a thermal surface can be ruled out and a fully reflective one is unlikely." [72, page 1 (abstract)]
2.) Another issue worth serious discussion is the assumption that the surface will radiate like a blackbody. Since we are considering an object that (i) is in steady state and therefore in thermal equilibrium (by our assumptions), (ii) is likely nearly isothermal in the sense that the redshifted temperature $T\infty$ is independent of radius inside the object, and (iii) has an enormous optical depth, it seems unavoidable that the emission must be close to a blackbody." VI [72, page 15]
3.) "Therefore, the accreting gas in these systems reaches the compact object at the center with a considerable amount of thermal and kinetic energy. If the compact object is a black hole, this energy simply disappears through the event horizon. On the other hand, if the object has a surface, the energy will be thermalized and reradiated (once the system reaches steady state), giving a large surface luminosity that should be visible to a distant observer. **Observations can thus tell the difference between an event horizon and a thermalizing surface**." VI, [72, page 11f]

With these considerations both remaining alternatives of fig. 15 would be eliminated. But these theoretical arguments are not valid for all possible SMO's, especially they are **not valid for degenerated objects**. They are restricted to stellar objects like normal stars which are stable on account of a hot center (gas pressure). Therefore, the arguments of [27] are repeated:
Avery E. Broderick et al state: "That Sgr A* is indeed a black hole, i.e., contains a horizon, is implied by its spectral energy distribution (SED), which lacks the thermal bump associated with accretion onto a photosphere." Certainly, LI of GRT needs to falsify this challenging argument. First ideas: SGR A* is a supermassive degenerated star [26]. The chemical potential (Fermi potential μF) is different from zero, the kinetic energy of the infalling particles is converted to enlarge the object and becomes not thermalized or partly only. Further: Light emission from a degenerate object is more likely similar to LED than thermal. The magnetic fields create synchrotron radiation which is not thermal. It's more like flares" [27] Accretion onto a degenerated star does not result in a thermal bump. The kinetic energy of the infalling particles is needed to expand and enlarge the degenerated SMO..

Another possibility to prove LI of GRT: Origin of the flares of Sgr A*

On a webpage of the Royal Astronomical Society [80] one finds the following statement about the flares of Sgr A*: "How the flares occur exactly remains unclear. It was previously thought that more flares follow after gaseous clouds or stars pass by the black hole, but there is no evidence for that yet. And we cannot yet confirm the hypothesis that the magnetic properties of the surrounding gas play a role either." [81] The conclusion: Possibly these flare events originate from the interior of a SMO. Infalling matter heats up internal material which climbs up and creates a flare on the surface of the SMO similar to flares of the sun.

Normally, flares will arise within the boundary layers but possibly there are flares arising in regions of the surface outside the boundary layer. And also, there may be light signals from matter hitting the surface of SMO's outside this region.

A general remark

SMO's as discussed here are degenerated objects similar to e. g. neutron stars. If they exist then classical GRT is refuted because then there are no BH's. If these special SMO's don't exist then LI of GRT may remain valid, certainly since there could be other oness. On account of the infinite fall time, formula (21.9) in [30], no event horizon is reached and passed e. g. during a collapse. Instead, one will/could get another mode of a supermassive object with a radius arbitrarily close to the event horizon and outside of this other supermassive object the Kerr metric is (nearly) valid, [30].

With these considerations of chapter 11 (part I) it is recapitulated that the EHT image of Sgr A* from 12.5.2022 is explainable by classical GRT. Part II and III discuss observations which prove that this explanation is not the only one.

12 EHT image of Sgr A* from 12.5.2022 and LI of GRT - part II (23.6.2022)

Part II discusses a first fundamental step towards LI of GRT based on the EHT measurements of Sgr A* [68] - [76] and measurements of the spin value of Sgr A*. The applicated EHT measuring results are

(12.1)
$$d = 50\mu as \quad \text{[fig. 11 and table I of 72]}$$
$$\theta_g = GM/(c^2 D) = 5\mu as \quad \text{[page 12 of 72]}$$
$$a^* = 0.9375 \quad \text{[page 7 of 72]}$$

d: diameter of blackhole shadow of Sgr A*
θ_g : gravitational radius of Sgr A*
M: mass of Sgr A*
D: distance to Sgr A*
a^*: spin parameter of Sgr A*

The value of a^* is the result of Kerr GRMHD simulations of the EHT group. It fulfills two conditions

1.) r_{isco} and r_{ph} are smaller than in the case a^*=0 [fig. 3 in 29]
2.) r_{isco} and r_{ph} become amplified by curved spacetime (gravitational field)

Both effects together lead to the measured shadow of the black hole in fig. 13 $d = 50\mu as$. With other words: The ring like image of fig. 13 is the superposition of the enlarged photo sphere and the enlarged ring of the innermost parts of the accretion disk. The innermost part of the accretion disk is the well-known hot ring with radius r_{isco} [Fig.3 of 29]. Normally this ring and the photo sphere are different but in fig. 13 they are nearly the same. Within classical GRT this is caused by a high a* [Fig.3 of 29]. Choosing the EHT value of 0.9375 the image of Sgr A*, fig. 13, is quantitatively described by the Kerr metric **and proves classical GRT**. But there is a **contradiction with other observations of the spin paramete**r. In [20] and [14] one gets a^*=0.52 and a^*=0.65 much smaller than 0.9375. Within LI of GRT such a contradiction does not arise. (Another contradiction with observation is the spin direction. This is discussed afterwards, chapter 13).

Within LI of GRT one starts with the calculation of a SMO owning the mass of Sgr A*. By application of the Tolman-Oppenheimer-Volkhoff equation (TOV) such a SMO has the radius $r_{SMO} = 1.56 r_{SM}$ [25], [26]. These calculations rely on classical GRT and therefore they are like the calculation of neutron stars. The origin of the ring like image of fig. 13 is seen a little bit different from classical GRT. Using LI of GRT it is the enlarged superposition of the boundary layer (fire ring) of the SMO and its photo ring. Since both own nearly the same radii (~1.5 r_{SM}) for $a^* \cong 0$ no high a* is demanded.
The calculation of the apparent radius R_{app} of the SMO (and of the photo ring) is as follows. The apparent radius is the enlarged radius of r_{SMO} on account of gravitational lensing by the strong gravitational fields. Its value is calculated using equation (12.2) [formula (8), page 13 of 72]

(12.2)
$$\begin{aligned} R_{app} &= 3\sqrt{3}M, & r_{SMO} \le 3M \\ &= r_{SMO}\left(1 - \frac{2M}{r_{SMO}}\right)^{-1/2}, & r_{SMO} > 3M \end{aligned}$$

(12.2) is valid for the Schwarzschild metric (a^*=0) and approximately valid for low a^*. One gets:

(12.3)
$$\begin{aligned} R_{app} &= 1.56 \times 2M\left(1 - \frac{2M}{1.56 \times 2M}\right)^{-1/2} \\ &= 5.02M \end{aligned}$$

Converting to the diameter $d_{app} = 2R_{app}$ with $M = \theta_g$ one has $d_{app} = 50.2\mu as$ which is in good agreement with $d = 50\mu as$. The apparent radius of the photo ring is nearly the same.

Since the observed spin values of [20], [14] a^*=0.52 and a^*=0.64 are small the application of the Schwarzschild metric with a^*=0 is acceptable. Another low spin observation is discussed in chapter 13, fig. 20 and 21. Fig.3 of [29] gives some impression of the dependencies from a^*. The measurements of high values of a^* contradict with those of low values of a^*. Chapter 3 above gives some hints why these high measurements are biased by light from the boundary layer (fire ring) and therefore probably they are not correct.

13 EHT image of Sgr A* from 12.5.2022 and LI of GRT - part III (5.9.2022)

Part III discusses a second fundamental step towards LI of GRT based on the EHT measurements of Sgr A* [68] - [76]. Classical GRT demands a *spin direction* which contradicts with other observations. Appended are a further nice measurement of the spin value and of the variability of the accretion of SGR A*.

1.) At first the EHT measurement result concerning the inclination of the accretion disk:

„We then compute a synthetic 230 GHz image for an observer at an inclination angle of i "

$i = 30°$ [page 7 of 72]

The inclination angle $i = 30°$ means that the stars whose winds are accreted by Sgr A* do not lie on the galactic plane which means $i = 90°$ but within the galactic center in a plane tilted by 60 degrees relative to it. This is the reason why the images of M87* and Sgr A*, fig. 7 and 13, are so similar. Both are face-on images of their accretion disks. Face-on and edge-on s. fig.1.

This observation agrees with other observations of the stars in the galactic center. Castelvecchi [83] explains it: "This face-on orientation is also consistent with decades of observations of the structure of the Milky Way's central region …The black hole's accretion disk is supplied by matter flowing from stars that orbit Sagittarius A* in a disk about 0.3 parsecs (one light year) across, ... So the orientation of the accretion disk should match the disk of stars, rather than the larger-scale structure of the Galaxy…" Similar Freistetter [84]. So, it fits with the matter emitting stars of the kernel that the bright ring of fig. 13 is the inner edge of the accretion disk (or the boundary layer). Both, classical GRT and LI of GRT agree with these observations and accept a tilted accretion disk seen nearly face-on.

2.) Second what is the direction of the Sgr A* spin derived from the EHT measurements, fig. 13?

Classical GRT aligns the spin direction of the accretion disk with the spin direction of Sgr A*. LI of GRT doesn't do so at least for a low spin of Sgr A*. This is discussed in more detail:

Following LI of GRT nothing about the spin of Sgr A* and its direction is derivable from the image of fig.13. The SMO could have spin zero. Fig. 13 shows a SMO with radius $r = 1.56\, r_{SM}$ obeying the Schwarzschild metric at least approximately if the spin is low. The bright ring is the boundary layer caused by infalling matter. An innermost edge of an accretion disk is not seen though it could exist in principle.

Following classical GRT the bright ring in fig. 13 is interpreted as the innermost edge of the accretion disk. Its radius r_{isco} is near 1.5 rsm as the measurement shows. Such a small r_{isco} is not possible for a low spin. The theoretical dependency of r_{isco} from spin results in the Sgr A* spin $a^* = 0.9375$ and a spin direction vertical on the disk plane. [Fig. 3 of 29] or [12], [page 7 of 72]. This means a face-on spin of Sgr A* (and of the accretion disk).

So, classical GRT and LI of GRT may differ twofold – a different spin value (this was discussed before, chapter 12) and different spin directions.

These different predictions of the Sgr A* spin direction can be tested by other observations. This is done in the next step.

3.) What is the observed direction of the Sgr A* spin without using the EHT measurements, fig.13?

It is quite natural to assume that the mass and spin of Sgr A* is accreted over the centuries from all stars of the milky way. The averaged spin direction should then be vertical to the galactic plane. It doesn't matter that the actual accretion disk is face-on because the average is important. Common sense thus expects an edge-on image of the spin of Sgr A*. This might not matter but there is an observation which proves it. This is illustrated in fig. 17 and 18. Especially fig. 18 shows that the Sgr A* spin is vertical on the galactic plane. Fig. 17 and 18 resemble "the first all-sky survey performed by the eROSITA X-ray telescope on-board the SRG observatory" [85] and show "Gigantic hot-gas structures above and below the galactic disc are probably due to shock waves generated by past energetic activity in the center of our Galaxy." "The most likely explanation for these features is a massive energy injection from the Galactic Center in the past, leading to shocks in the hot-gas envelope of our Galaxy." [85].

Counter-arguments to explain a tilted spin axis are Castelvecchi [83]: several explosions of supernova instead or Freistetter [84]: possibly there was a collision with another smaller galaxy. "Es kann sein, dass unsere Milchstraße in der jüngeren Vergangenheit (das heißt vor ein paar hundert Millionen oder wenigen Milliarden Jahren oder so) mit einer kleineren Galaxie verschmolzen ist." These counter-arguments look artificial

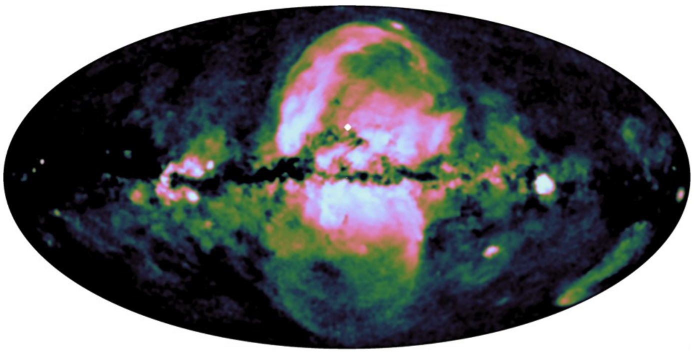

Fig. 17 The eROSITA bubbles.
This is the observed image of the eROSITA bubbles and basis of the illustration of fig. 18. "In this false-colour map the extended emission at energies of 0.6-1.0 keV is highlighted. The contribution of the point sources was removed and the scaling adjusted to enhance large-scale structures in our Galaxy." [85].
© MPE/IKI Taken from MPI [85] and [86]

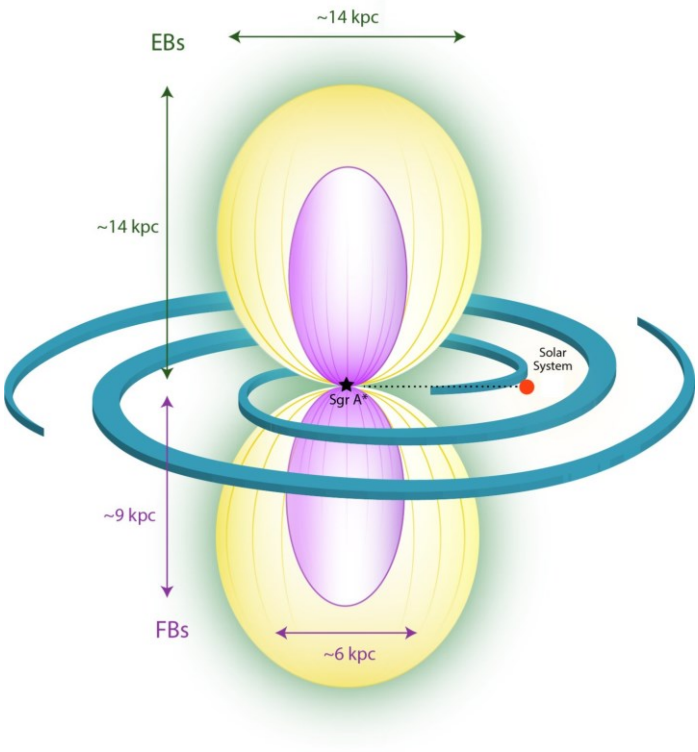

Fig. 18 “Schematic view of the eROSITA (yellow) and Fermi bubbles (purple). The galactic disk is indicated with its spiral arms and the location of the Solar System is marked. The eROSITA bubbles are considerably larger than the Fermi bubbles, indicating that these structures are comparable in size to the whole galaxy.” [85] This illustration of the measurement results of fig. 17 shows that the Sgr A* spin is vertical on the galactic plane.
© MPE/IKI Taken from MPI [85] and [86]

4.) A further observation preferring a boundary layer

The Sgr A* luminosity may have two different origins. Following classical GRT it originates from the inner edge of the accretion disk and this is the bright ring of the EHT Sgr A* image of fig. 13. Following LI of GRT the Sgr A* luminosity originates from the boundary layer and instead this is the bright ring in fig. 13, see chapter 12. As investigated by Murchikova et al [87] both origins would emit light with a different variability and the observed one of Sgr A* fits with the variability of light from a boundary layer. More details see [87] and some comments [88]. One can argue: If there is no light with high variability then there is no light from an accretion disk and especially no light from its inner edge. So, the bright ring of fig. 13 is not fully explained by the simulations of EHT [67]-[72] since they make use of accretion disks, but a boundary layer remains possible.

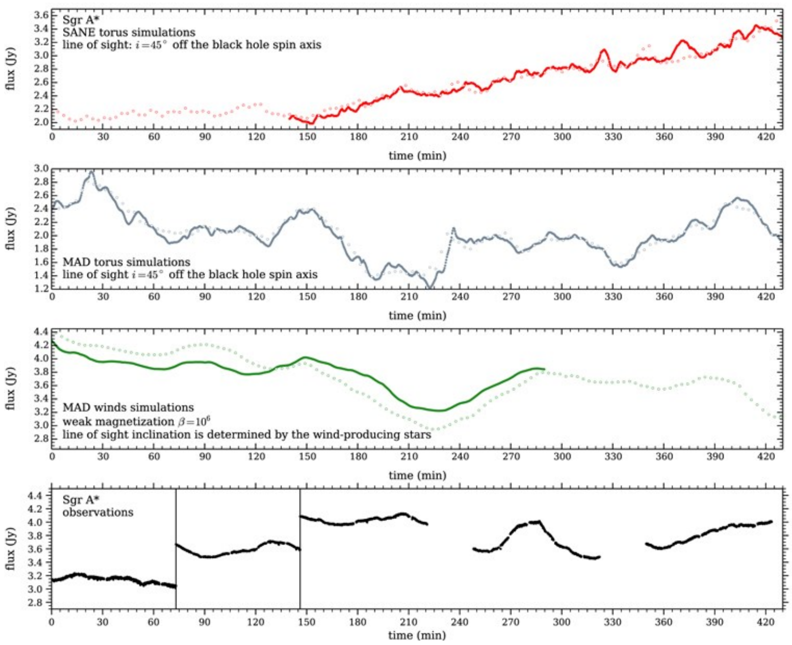

Fig 19 Variability of light from accretion disks (first two rows), from wind accretion (third row) and observed variability of Sgr A* (last row). The last two rows are flatter then the first two ones and visualize less variability. More details see [87]. Fig. 19 is taken from [87], fig.1.

5.) Observation of a low spin of Sgr A* - 22.10.2022

The observation of a low spin of Sgr A* - a*<= 0.1 - contradicts classical GRT since the EHT observations of Sgr A* predict a high spin a* = 0.9375, see formula (12.1).

The observation of a low spin was done by Giacomo Fragione & Abraham Loeb. 2020. *An Upper Limit on the Spin of SgrA* Based on Stellar Orbits in Its Vicinity.* [89]. Background information is given by: Ali B., Paul D., Eckart A. et al. 2020 *Kinematic Structure of the Galactic Center S Cluster* [90]. Helpful explanations are given by:Nadja Podbregar *Astronomen grenzen Eigendrehung von Sagittarius A* mithilfe von Sternenbahnen ein* [91], *Neue Erkenntnisse zur Rotation von Sagittarius A** 23/10/2020 [92], *Milky Way's Supermassive Black Hole is Spinning Slowly, Astronomers Say* Oct 28, 20 [93], Harvard-Smithsonian Center for Astrophysics October 15, 2020 *The spin of the supermassive black hole in the Milky Way* [94]

The main idea: One has observed that many stars of the S cluster which are stars near of and surrounding Sgr A* are distributed in two edge-on planes. It is rational to assume that these stars in the same plane are borne at the same time. Their estimated age is about 10^7 to 10^8 years. During this time gravitational forces depending on the spin value of Sgr A* (Lense Thirring-effect or frame dragging effect) turn the stars around by different angles and if the spin is high enough the original common plane disappears. Since this is not the case up today the spin of Sgr A* has to be low. The calculations prove an upper limit a* <= 0.1.

Fig. 20 illustrates the S cluster. The two edge-on planes are not so easy to see. Therefore, in Fig 21 all ellipses are reduced to circles of the same size but without changing the directions of the ellipses

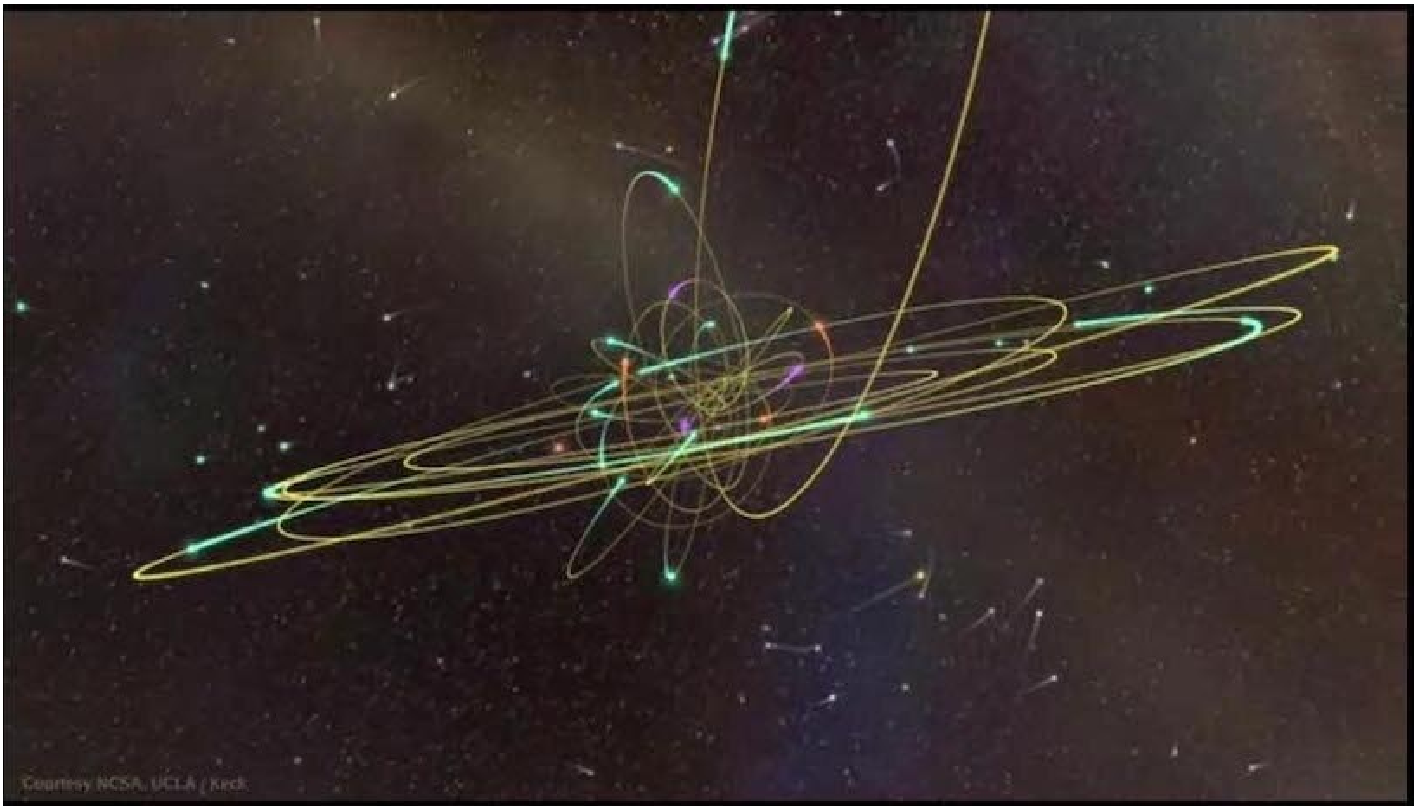

Fig. 20 A schematic showing the motions of stars around the supermassive black hole in the center of our galaxy – so called S stars. The stars lie in edge-on planes, and astronomers have used this constraint to deduce that the spin a*of the black hole must be less than about 0.1. Taken from [94] Credit: Barker, Patterson, & Spivey; U. Ill. NCSA Advanced Visualization Laboratory

These considerations with other words, cited from [94]:

"CfA astronomers Giacomo Fragione and Avi Loeb realized that the spatial distribution of one group of cluster objects, the so-called S-stars, could be used to probe the spin. There are currently about forty known S-stars that orbit the SMBH in as little as 9.9 years, and recent analyses argue that collectively they lie in two nearly edge-on disks, with the stars in each disc rotating around the black hole but in opposite directions. The two astronomers realized that this unusual geometry could allow an estimate measurement of the spin. One of the more curious and non-intuitive predictions of relativity is that space is not only warped by the gravity of a massive body, it is also warped (though to a lesser degree) by the spinning of a body. This is the so-called "frame dragging effect," a small and hard-to-measure phenomenon (which, however, been confirmed). The two astronomers show that in the case of SgrA*, frame dragging will have an appreciable effect on the orbits of the S-stars in these disks. By assuming that the S-stars orbital planes are stable over time, they are able to show that the spin of the SMBH in the Milky Way must be less than about 0.1." [94]

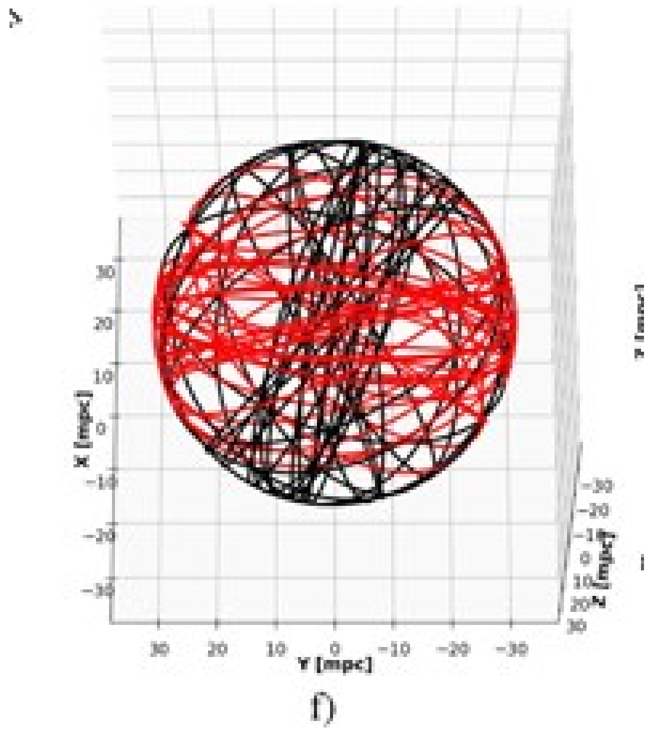

Fig. 21 Visualizations of the distribution of the S-cluster stars. All orbits of fig. 20 are reduced to circular ones without changing their direction. The two edge-on planes become visible. Taken from fig. 4 of [90]

6.) Some comments about the Sgr A* observations

6.1) Genzel revised his comments about BH's of chapter 8. The EHT measurements of Sgr A*, fig. 13, prove the predictions of classical GRT so exactly that no doubt remains.[95].Literally:"The stars that we have been looking at orbit about 1,000 times farther away from the black hole [than the event horizon]," Genzel said. "So there was a slight possibility that there could be some configuration of mass at a distance of less than 1,000 times the event horizon other than a black hole."
The Event Horizon Telescope has now provided the missing piece of evidence.
"We have known that the event horizon should be 50 micro arc seconds in diameter," Genzel said. … "That's exactly what the Event Horizon Telescope team found. With that, we can throw out all the other possible explanations of this mass. I think there cannot be any doubt anymore that Sagittarius A* is a black hole." [95]
But LI of GRT predicts with the boundary layer of a supermassive object with radius

$$r = 1.56\, r_{SM}$$

the EHT observations as well.

6.2) The ALMA image of Sgr A*, fig. 1 of [27], was the precursor of the EHT image of SGR A*, fig. 13. The former comments might be interesting:
A (first) explanation of S. Issaoun and H. Falcke: "the radio jet is pointing almost at us" [10] of [27] and we are looking at a bright emission center hiding the shadow. A contrived model? More likely, the directions of total angular momentum of the galaxy and of SGR A* should be (more or less) the same. But such an argument confirms another view: There is no doubt that the BH simulations and the ALMA observations don't fit together.[27] p. 1 or in German:"Letzteres könnte die Ergebnisse der GRAVITY-Beobachtungen bestätigen, nach denen uns das Schwarze Loch frontal zugekehrt ist. „Das bedeutet, dass wir das ‚Biest' unter einem besonderen Blickwinkel sehen", erklärt Issaouns Kollege Heino Falcke." [96]
The actual opinion of the author (j. b.): the direction of the accretion disk is face-on but the spin of Sgr A* has the direction of the galactic plane.

6.3) Avery E. Broderick et al. [11] and [12] of [27] state: "That Sgr A* is indeed a black hole, i.e., contains a horizon, is implied by its spectral energy distribution (SED), which lacks the thermal bump associated with accretion onto a photosphere (Broderick & Narayan 2006; Broderick et al. 2009)." This argument became part of the EHT observation of M87* and SGR A*, e. g. [72]. But the lack of the thermal bump is expected for degenerated stars as well [27], p 2.

6.4) Some nice questions (and answers) in the following discussion: **About the non-intuitive announcement at 12 May 2022 of the EHT team that spin axis of Sgr A* Black Hole facing Earth?**
"What is this all about?: At 12 May 2022 at the ESO official announcement live streaming event the EHT representatives claimed that the Sgr A* BH accretion disc spin axis is sort of facing Earth's position thus BH spin axis possible not perpendicular to the Milky way galaxy accretion disc?!. This if true, is an unexpected result and raised a lot of eye brows!!, I am not satisfied from the given explanation. Are there any alternative explanations?" [97]

6.5) **Talk-DPG-2023-Questionable predictions of SgrA.pdf**. This pdf-file summarizes ideas of chapter 13. Some citations: "On one side there is the famous EHT image of Sgr A* [fig. 22] on the other side there are at least three questionable predictions of Sgr A* characteristics by the EHT group contradicting observation: a*=0.9375 against a*=0.15; spin direction "face-on" against "edge-on"; accretion light variability arising with accretion disks against variability of accretion wind. And there is a theoretical short-cut by Broderick et al.: The missing UV bump agrees with *degenerate* supermassive objects being no BH. We start with the arguments of Broderick et al. to prove an event horizon."

14 Summary

The brightness of sector SEE in fig. 2 of Krzysztof Nalewajko, Marek Sikora and Agata Rózànskà [8], and the ALMA VLBI measurements of SGR A* [9] present open questions concerning the shadow of M87* and of SGR A* which are explainable by LI of GRT – chapter 2 and 4. The same is true for the conflicting high and low spin measurements of M87* and SGR A* - chapter 3. Since SGR A* is seen more edge on than M87* an EHT image of SGR A* should become a deeper test of LI of GRT. A possible direct measurement of the SMO/BH period - chapter 5 – as well as different Hubble parameters – chapter 6 - and the anisotropy observations – chapter 7 - might refute BH's. Measurements of chapter 9 might yield a low spin and therefore refute BH's, too. Following Nobel prize winner Genzel there is none well proven first image of a BH - chapter 8. The observations of Cen X-4 - Chapter 10 – favor LI of GRT. Chapter 11 (part I): One important statement of the EHT group in VI [72] is that "the question of whether [fig. 13] is a true black hole remains unresolved." Chapter 12 (part II) and chapter 13 (part III) discuss first fundamental steps convincingly testing LI of GRT. They are based on the EHT Sgr A* measurements of *spin size* and *spin direction* – fig. 22.

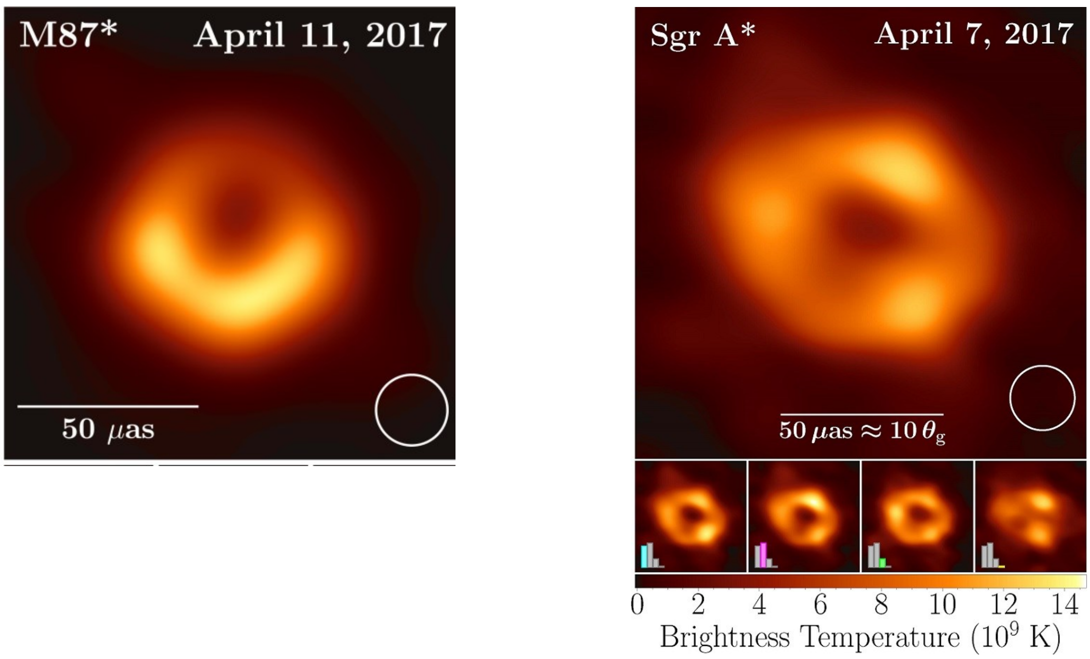

Fig. 22 EHT images of M87* and Sgr A*.
The bright rings are interpreted as

- the photo ring and the innermost edge of an accretion disk (**classical GRT**) or
- the boundary layer of a supermassive object with radius $r = 1.56\, r_{SM}$ (**LI of GRT**)

Classical GRT agrees with the EHT measurements of Sgr A* and M87* but needs a high spin parameter a^* and thus contradicts with low spin measurements of Sgr A* and M87* [20][14] and fig. 21, [90]. **LI of GRT** agrees with the EHT measurements of Sgr A*and M87* *as well as* with low spin measurements of Sgr A* and M87*. Above, LI of GRT has the concepts explaining why high spin values of Sgr A* are not correct since their measurement might be biased by light from the boundary layer (s. chapter 3). Newest (2022): **classical GRT** demands a Sgr A* *spin direction* in contradiction with other observation [86], chapter 13.

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