Deutsche Physikalische Gesellschaft
Frühjahrstagung SMuK März 2023
Fachverband GR

Questionable predictions of Sgr A* characteristics by the EHT group

J. Brandes

Talk March 2023
last update: 17.3.2023
preliminary version

1 Introduction and summary

On one side there is the famous EHT image of Sgr A*, fig. 2, 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.

2 The arguments of Broderick et al. to prove an event horizon:

The main idea to prove an event horizon: If there is no black hole but some supermassive object then accreting matter hits the surface of the supermassive object and the kinetic energy becomes thermalized and radiates away. This radiation results in an UV bump (which is not observed). But if there is a black hole then the accreted matter passes the event horizon without losing kinetic energy by radiation and without creating an UV bump (which agrees with observation).

The short-cut: If there is a *degenerate* object e. g. similar to white dwarfs, neutron or quark stars then the accreting matter is taken to enlarge the degenerate object and this consumes kinetic energy because the Fermi edge has to be overcome and no UV bump will arise, too. [5] and [13] give an example of a supermassive, degenerate object having no event horizon.

In more detail: At first some citations of Broderick et al.

"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*. [1]**

"Accretion onto compact objects with a surface, e.g., white dwarfs, neutrons stars, results in the formation of a boundary layer in which any remaining kinetic energy contained within the accretion flow is thermalized and radiated. In contrast, gas accreting onto a black hole is free to advect any excess energy across the horizon without further observational consequence. If the mass accretion rate can be independently estimated, this difference provides an observational means to distinguish between the presence of a surface, or more accurately a "photosphere," and a horizon" [4]

"Therefore, Sgr A* must have an event horizon behind which the kinetic energy of the infalling accreting gas is hidden." [4]

"We consider a model in which Sgr A*, the 3.5x10^6 M_{sun} supermassive black hole candidate at the Galactic Center, is a compact object with a surface. Given the very low quiescent luminosity of Sgr A* in the near infrared, the existence of a hard surface, even in the limit in which the radius approaches the horizon, places severe constraints upon the steady mass accretion rate in the source, requiring dM/dt < 10^-12 M_{sun} /yr. This limit is well below the minimum accretion rate needed to power the observed submillimeter luminosity of Sgr A*. We thus argue that Sgr A* does not have a surface, i.e., it must have an event horizon. The argument could be made more restrictive by an order of magnitude with microarcsecond resolution imaging, e.g., with submillimeter VLBI." [2,3]

These citations prove that the existence and creation for degenerate objects is not taken into consideration. But **they also prove that the theory of Broderick et al. has a very convincing kernel**. It proves that an alternative to black holes cannot be some ordinary stellar objects since the measured temperatures are not high enough. It proves that alternatives to black holes if there are ones have to be *degenerate* objects. This is the case for the alternative of the Lorentz interpretation [5], [13].

When degenerate objects (neutron stars, white dwarfs, or possibly quark stars) grow you will need an energy supply. In order to occupy higher energy levels, accretion energy of the infalling matter is required. If the volume of the degenerate object does not change, energy levels become occupied, all of which are greater than the Fermi momentum p_F. Only if the volume of the degenerate object increases then there are new, unoccupied energy levels less than the Fermi momentum p_F or the Fermi Energy E_F.

The calculation of supermassive, degenerate objects by the author [5], [13] using the TOV (Tolman-Oppenheimer-Volkoff equation) shows both effects. As the total mass increases, the radius in Schwarzschild units remains nearly constant (1.56 r_{sm}), but this means an increase in volume in usual units. On the other hand, the central density ne and thus p_F also increases as the total mass grows, see formula (1). As density ne increases, p_F rises. If the density of a degenerate object becomes arbitrarily large and this assumption is obvious, if one assumes that a black hole does not form, then p_F becomes arbitrarily large and there is no energy left for the thermalisation.

In both cases, accretion energy is consumed and not thermalised. This effect has not been investigated in [1] - [4]. But **the formation of degenerate objects has some properties of black holes**. The latter absorbs kinetic energy from particles that pass the event horizon, but degenerate objects transform kinetic energy into excited states of the degenerate object. In both cases, the thermalisation of the falling matter is completely or partially avoided.

(1)
$$n_e = \frac{8\pi}{3\cdot h^3} p_F^3$$

The formular (1) shows: As fermion density n_e increases, the Fermi momentum p_F increases as well. If the density of a degenerate object becomes arbitrarily large and this assumption is obvious, if one assumes that a black hole does not form, then p_F becomes arbitrarily large and there might be no energy left for the thermalisation.

The formula (1) for p_F follows from general considerations. The author follows Hanslmeyer, Chapter 9.1.5 [6]:

Fermions include particles with half-number spin, e. g. electrons or other elementary particles such as quarks and core components. For them, the *Pauli principle* applies: Each quantum cell of a 6-dimensional phase space

(2) $(x,y.z,p_x,p_y,p_z)$

shall not contain more than two fermions, in our case electrons.

The volume of such a quantum cell (or phase space cell) is:

(3) $h^3=dp_x\, dp_y\, dp_z\, dV$

So if we look at a shell $[p,p+dp]$ in the momentum space, then there are $4\pi p^2 dV/h^3$ quantum numbers that do not contain more than $8\pi\, p^2 dV/h^3$ electrons. So, from quantum mechanics, the condition follows:

(4) $f(p)\, dp\, dV <= 8\pi\, p^2 dV/h^3$

$f(p)$ gives the number of particles in the range $dp\, dV$. This is derivable by quantum mechanics using the formula of the Fermi-Dirac distribution.

The state in which all electrons have the lowest energy without violating the *Pauli principle* is that in which all phase space cells are equipped with two electrons up to the momentum p_F. All other phase space cells, however, are empty:

(5) $f(p)=8\pi\, p^2/h^3 \qquad p<=p_F$

(6) $f(p)=0 \qquad p>p_F$

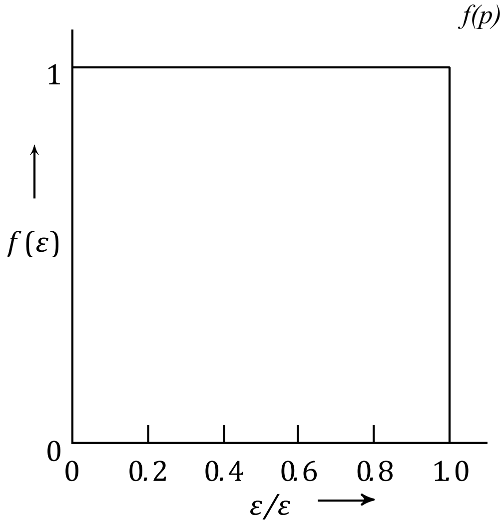

Fig. 1: Illustration of formulas (5) and (6). $f(p)$ is constant >0 if $p<=p_F$. and $f(p)=0$ if $p>p_F$. Taken from [7]

From this, it is to be inferred:

(6) $$n_e\, dV = \int_0^{pF} \frac{8\pi P^2\, d\rho}{h^3} = \frac{8\pi}{3h^3} p_F^3\, dV$$

That's the formula (1) above.

3 At least three Sgr A* characteristics predicted by the EHT group contradict with astronomical observations

As explained in [12], there are a number of astronomical observations that contradict with the properties of black holes in classical general theory of relativity. Three of them relate to characteristics of Sgr A* as predicted by the EHT group. These are

1.) a^*=0.9375 against a^*=0.15;
2.) spin direction "face-on" against "edge-on";
3.) accretion light variability arising with accretion disks against variability of accretion wind.

These details are presented in chapter 13 of [12] together with a series of illustrations and should not be repeated here. If, for the sake of simplicity, the independent astronomical observations are assumed as correct, which could change by more detailed examination, then the too high spin a*=0.9375 has special significance. A *high* spin value fits with the observed radius of the light ring seen in the EHT image of Sgr A* (and also of M87*, see fig.2). The light rings in fig. 2 are understood as the "innermost stable circular orbit" with radius r_{isco} of a "thin accretion disk". Figure 3 of [8] explains the quantitative relationship between r_{isco} and spin. If the spin is nearly zero, as the observation shows, $r_{isco} \sim 6\, r_{sm}$ is too large to be the radius of the light ring of the EHT image. However, since it is the innermost area of the accretion disc, which glows brightly due to special, frictional effects and thus explains the brightness of the black holes in the galactic centers, this explanation for the bright glow of the galactic black holes is ruled out. The mapping of r_{isco} and brightness of Sgr A* is standard, see [9]

The three contradictory observations combined exacerbate this problem. They contradict the standard assumption that the accretion of matter to black holes is carried out by means of a "thin accretion disk" and is therefore radiation intensive. Observation 1.) excludes that the light ring in the Sgr A* image is the innermost area of an accretion disc, because r_{isco} is too large. Observation 2.) gives an accretion disc the wrong direction, it should be "edge on". In the same way, observation 3.) contradicts a heating and radiation due to friction like processes of the accretion disc because 3.) means accretion in larger chunks. The black hole does not feed with "porridge" but devours "fresh flesh". [10].

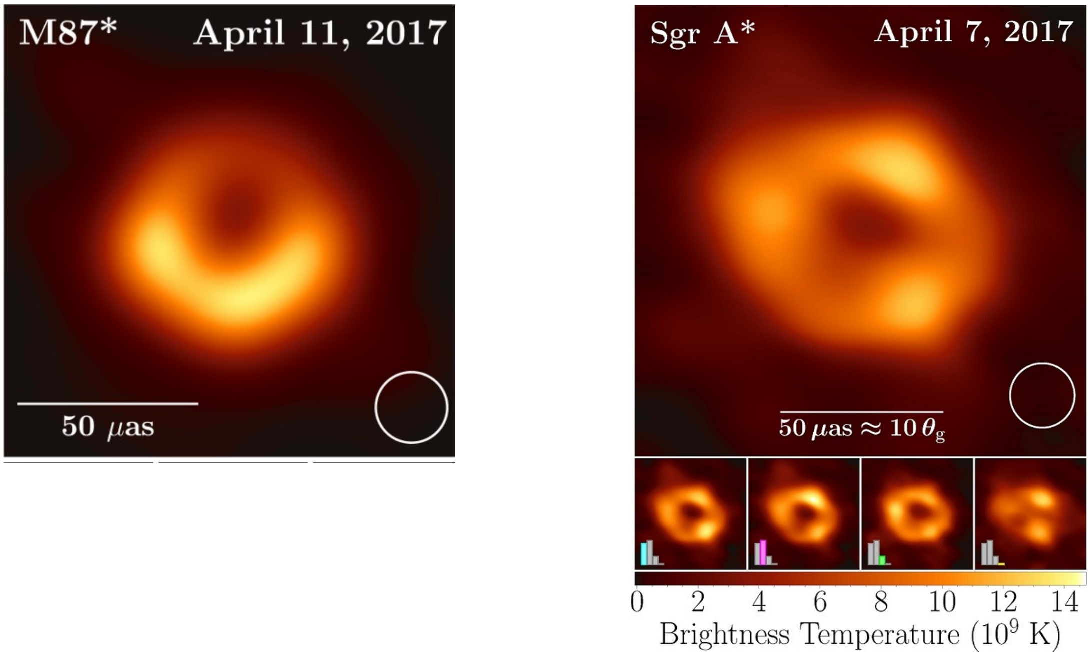

Fig. 2 Famous EHT images of M87* and Sgr A*.

4 Literature

[1] First Sagittarius A* Event Horizon Telescope Results. VI. Testing the Black Hole Metric, chapter 4.
First M87 Event Horizon Telescope Results. VI. The Shadow and Mass of the Central Black Hole, chapter 9.4

[2] Avery E. Broderick and Ramesh Narayan: *On The Nature of the Compact Dark Mass at the Galactic Center,* 31.3.2006, arXiv:astro-ph/0512211v2

[3] Avery E. Broderick, Vincent L. Fish, Michael D. Johnson, Katherine Rosenfeld, Carlos Wang, Sheperd S. Doeleman, Kazunori Akiyama, Tim Johannsen, and Alan L. Roy: MODELING SEVEN YEARS OF EVENT HORIZON TELESCOPE OBSERVATIONS WITH RADIATIVELY INEFFICIENT ACCRETION FLOW MODELS, The Astrophysical Journal, 820:137 (16pp), 2016 April 1

[4] Avery E. Broderick (1,2), Ramesh Narayan (3), John Kormendy (4,5,6), Eric S. Perlman (7), Marcia J. Rieke (8), Sheperd S. Doeleman *The Event Horizon of M87* arXiv:1503.03873v2 [astro-ph.HE]

[5] *Supermassive objects (SMO's) calculated using the Tolman Oppenheimer Volkoff (TOV) equation and possible observation by gravitational waves (GW's) and by the event horizon telescope (EHT),* see homepage of the author: http://www.grt-li.de

[6] Arnold Hanslmeyer, *Einführung in Astronomie und Astrophysik*, 2. Aufl. Spektrum Verlag 2011, Chapter 9.1.5

[7] Anthony Brown, *Some notes on the ideal fermion gas* 08.04.2013, brown@strw.leidenuniv.nl

[8] *Measuring results of M87 and Lorentz interpretation (LI) of GRT,* see homepage of the author: http://www.grt-li.de

[9] This shows a comment in [4]: "Doeleman et al. (2012) associate the 1.3mm compact emission with the ISCO of the M87 black hole, enlarged by the strong gravitational lensing that occurs at small radii."

[10] Nadja Podbregar 27. Juni 2022, https://www.scinexx.de/news/kosmos/milchstrasse-schwarzes-loch-speist-rohkost/

[11] Anthony Brown *Some notes on the ideal fermion gas,* 08.04.2013, brown@strw.leidenuniv.nl

[12] Homepage of the author: http://www.grt-li.de, please, look at first: Observations questioning classical GRT and preferring LI of GRT – EHT image of M87*, Spin, ALMA image of SGR A* and more, chapter 13.

[13] Brandes, J.; Czerniawski, J. (2010): *Spezielle und Allgemeine Relativitätstheorie für Physiker und Philosophen - Einstein- und Lorentz-Interpretation, Paradoxien, Raum und Zeit, Experimente*, Karlsbad: VRI, 4. erweiterte Auflage