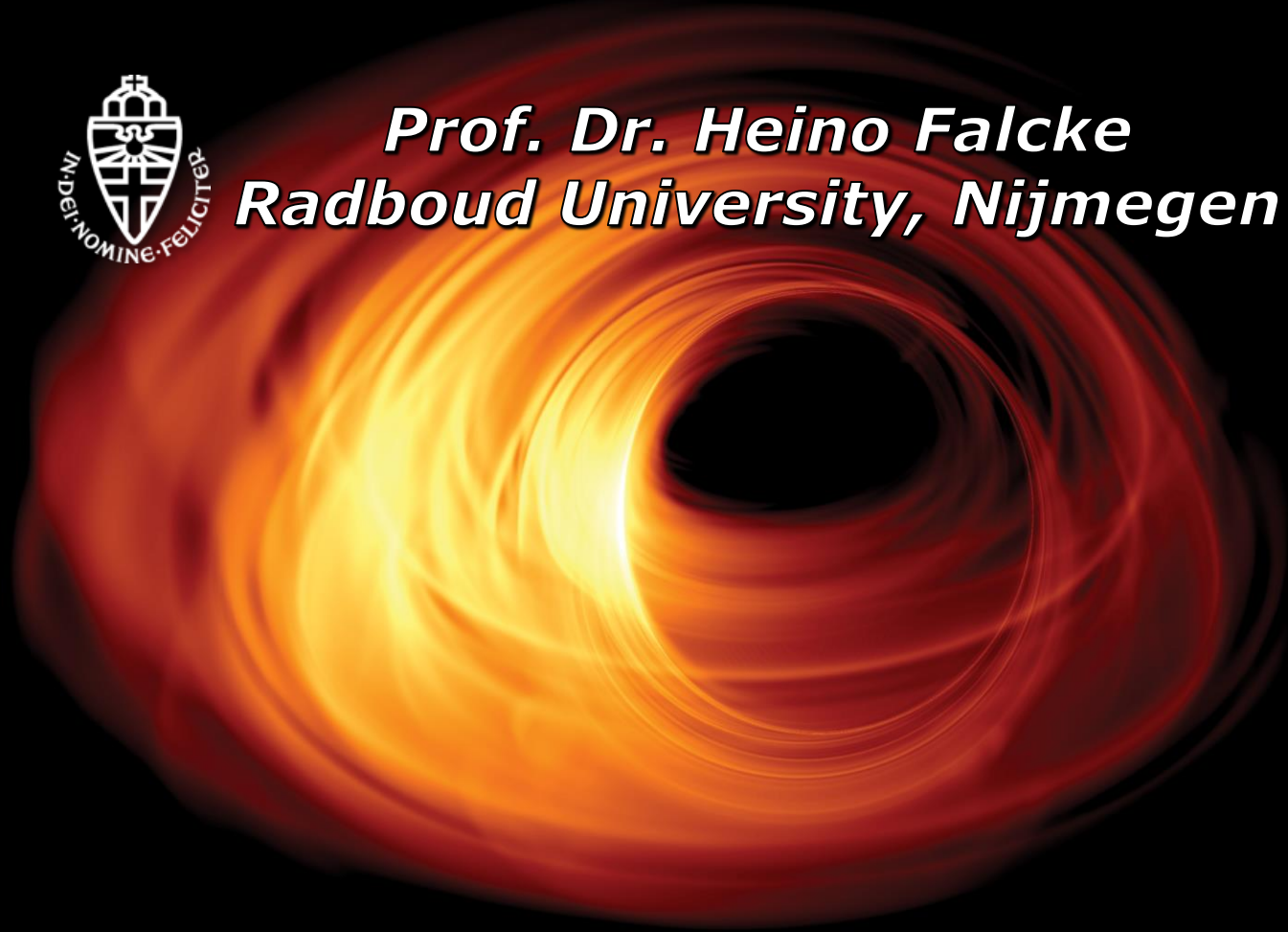


To the End of Space and Time



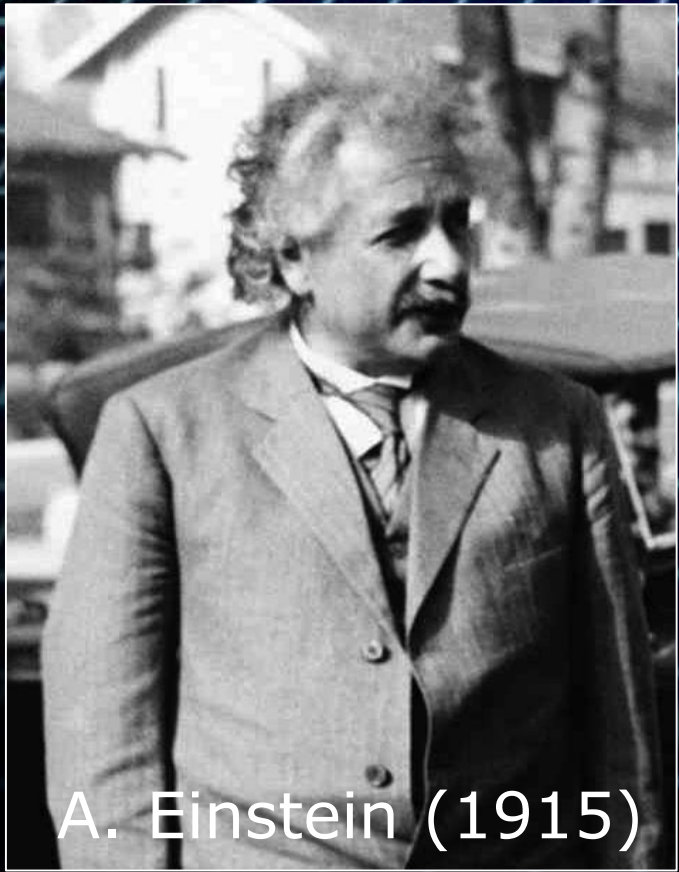
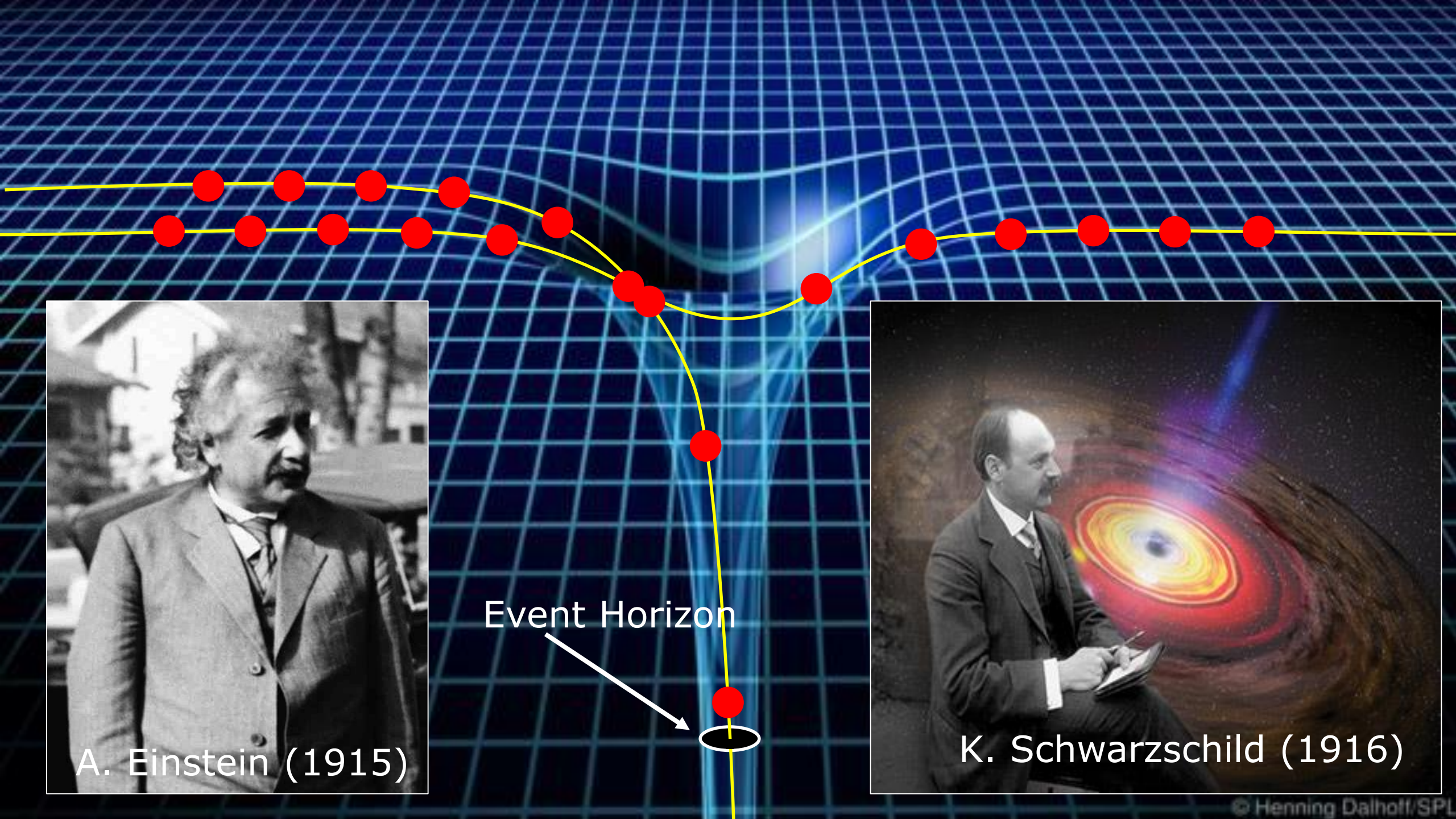
Prof. Dr. Heino Falcke
Radboud University, Nijmegen



A thousand years in your sight, are like a day that has just gone by, or like a watch in the night.

Psalm 90:4





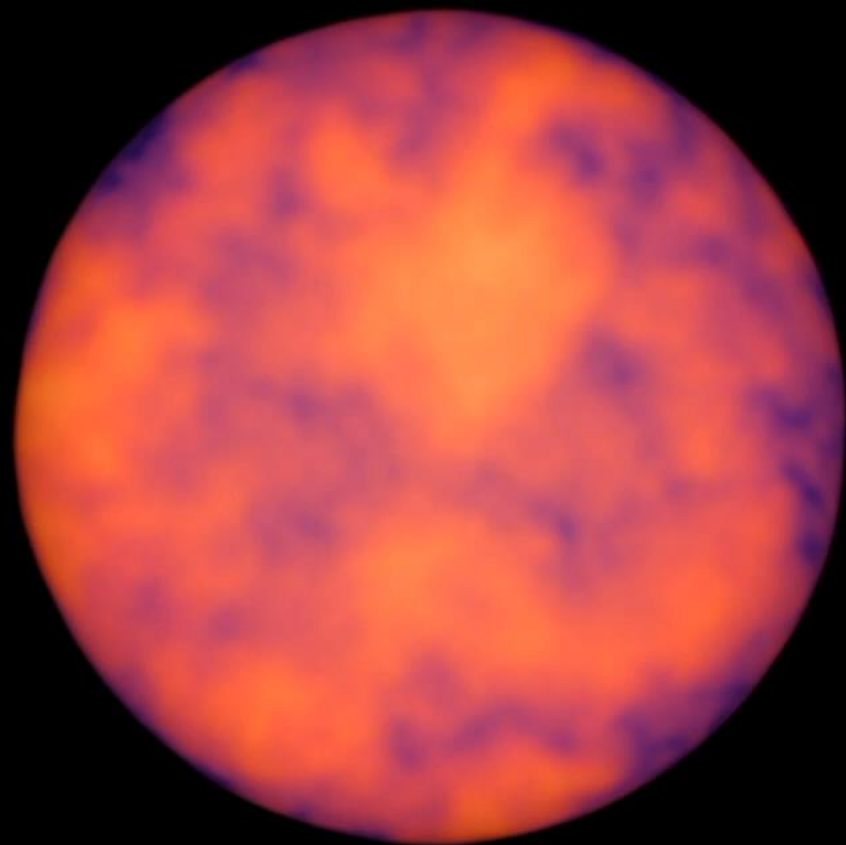
A. Einstein (1915)



K. Schwarzschild (1916)



Rosetta Nebel (IPHAS)

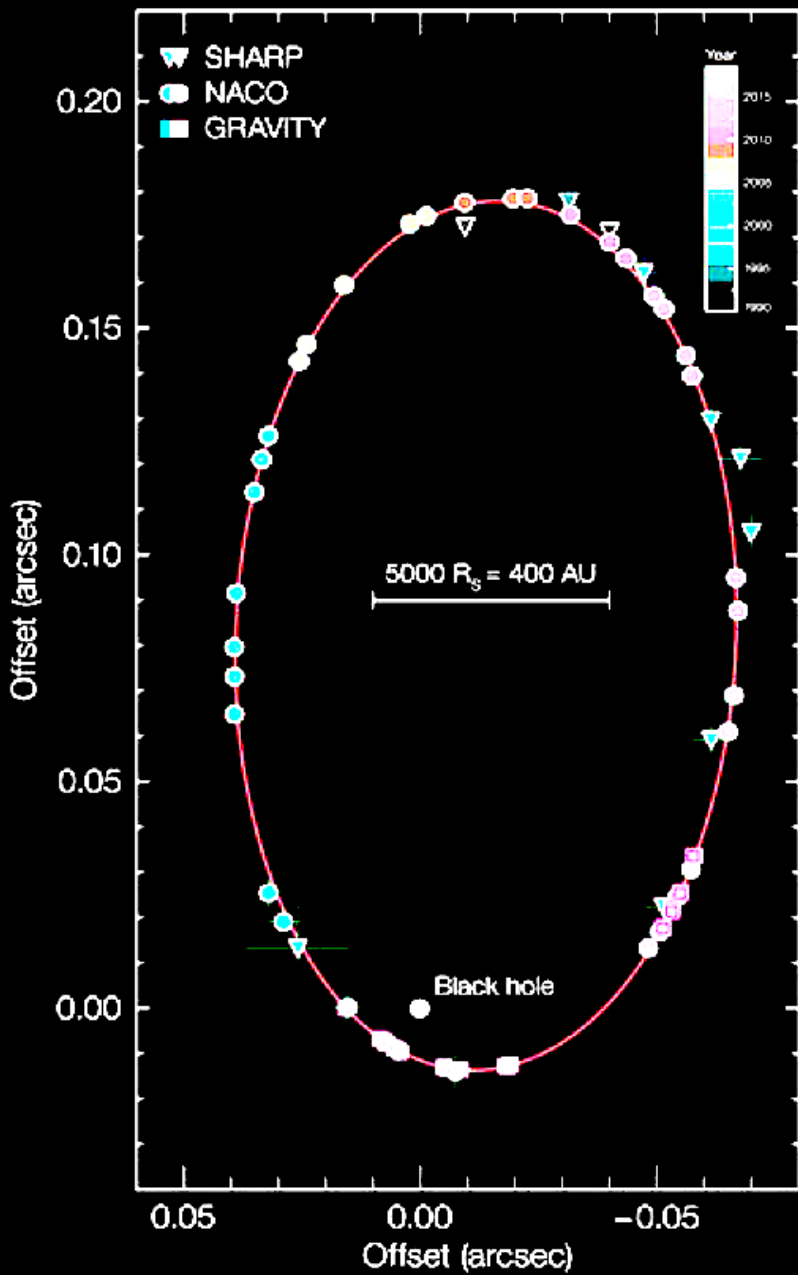




SNR 0509-67.5 (STScI/NASA/ESA)

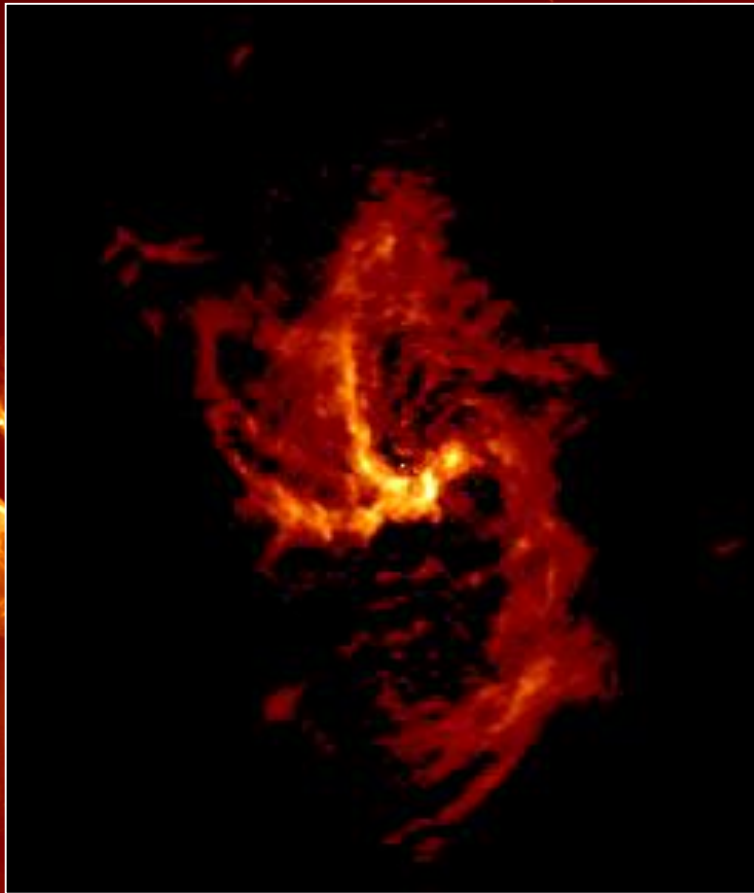


Andromeda Galaxie (R. Gendler)



ESO/GRAVITY (2018)

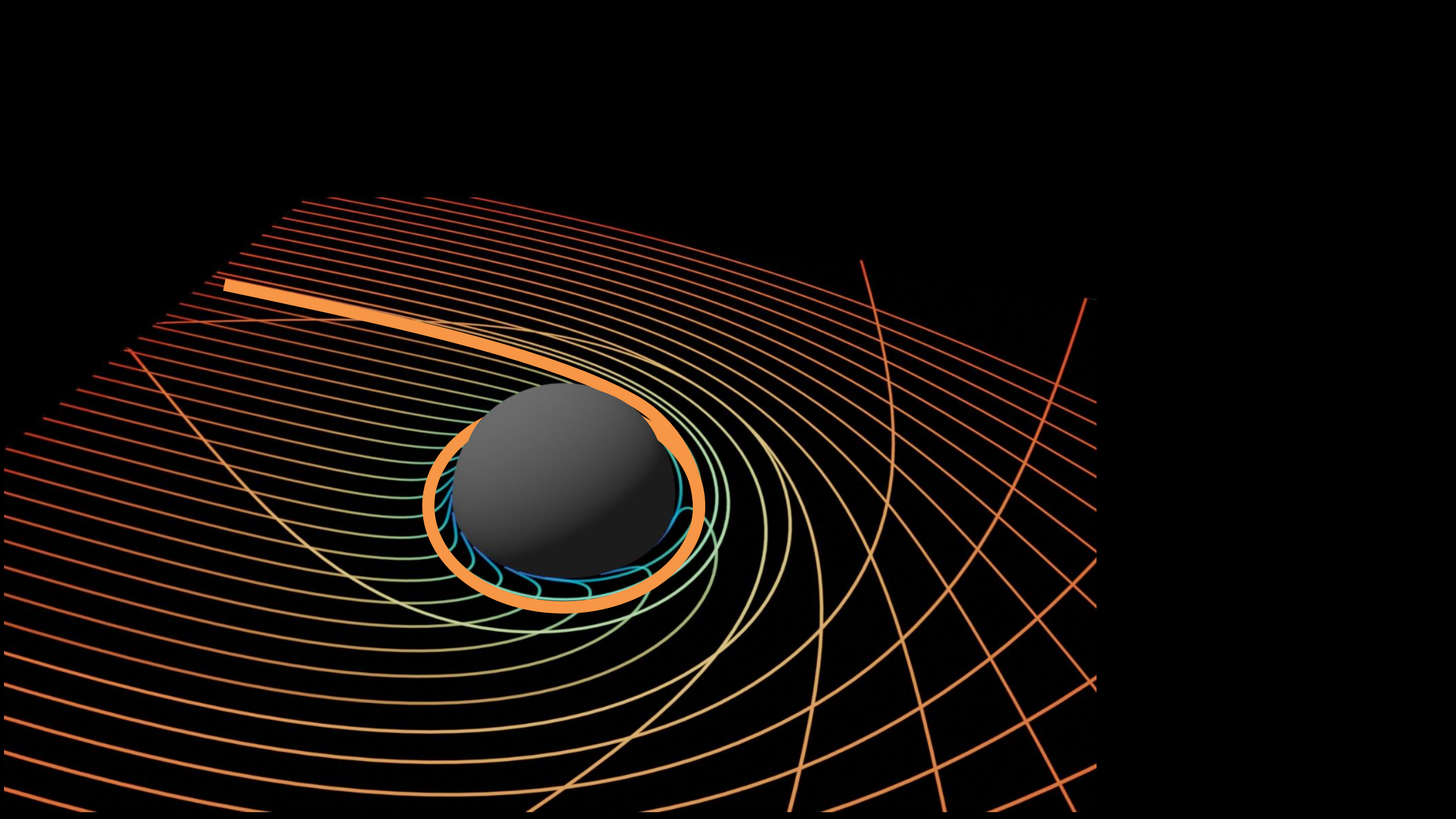


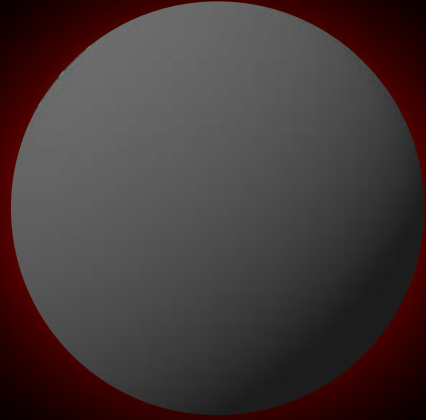


Central parsec in radio
VLA: Zhao & Morris
Sgr A*: Balick & Brown (1974)

0.5° ~ 75 pc ~ 240 ly

MeerKat (SouthAfrica)
Heywood et al. (2019)





Falcke, Agol, Melia (2000, Astrophys. Journal)

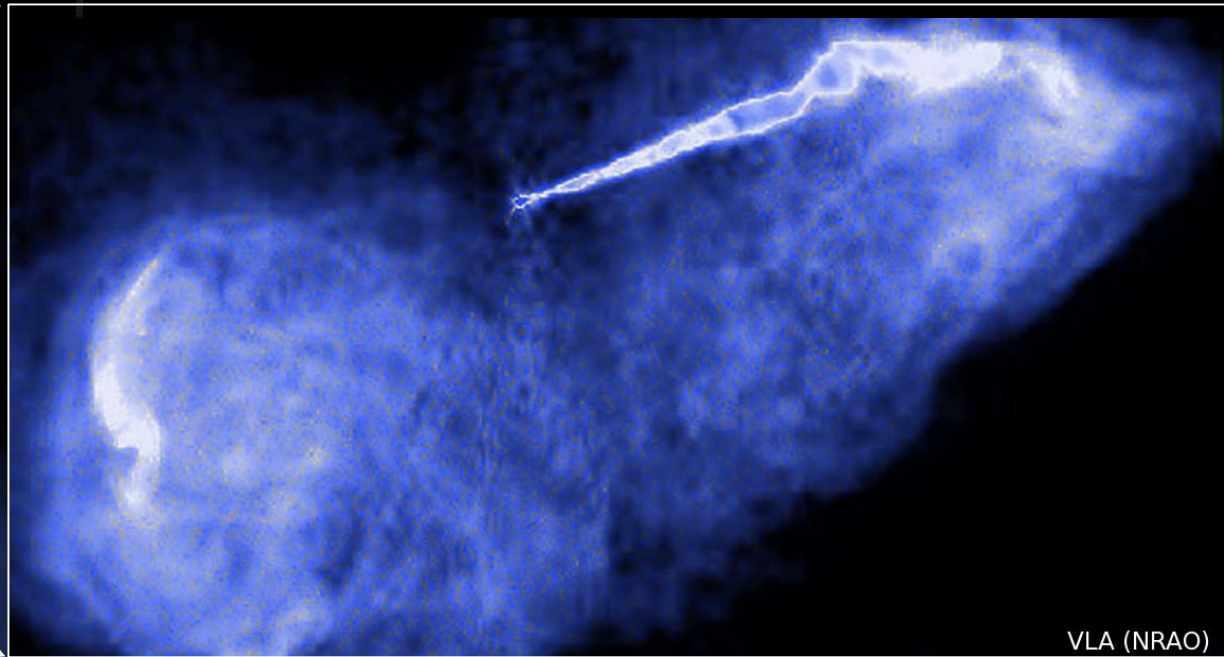




optical
Messier 87 (M87)

radio

240.000 lightyears

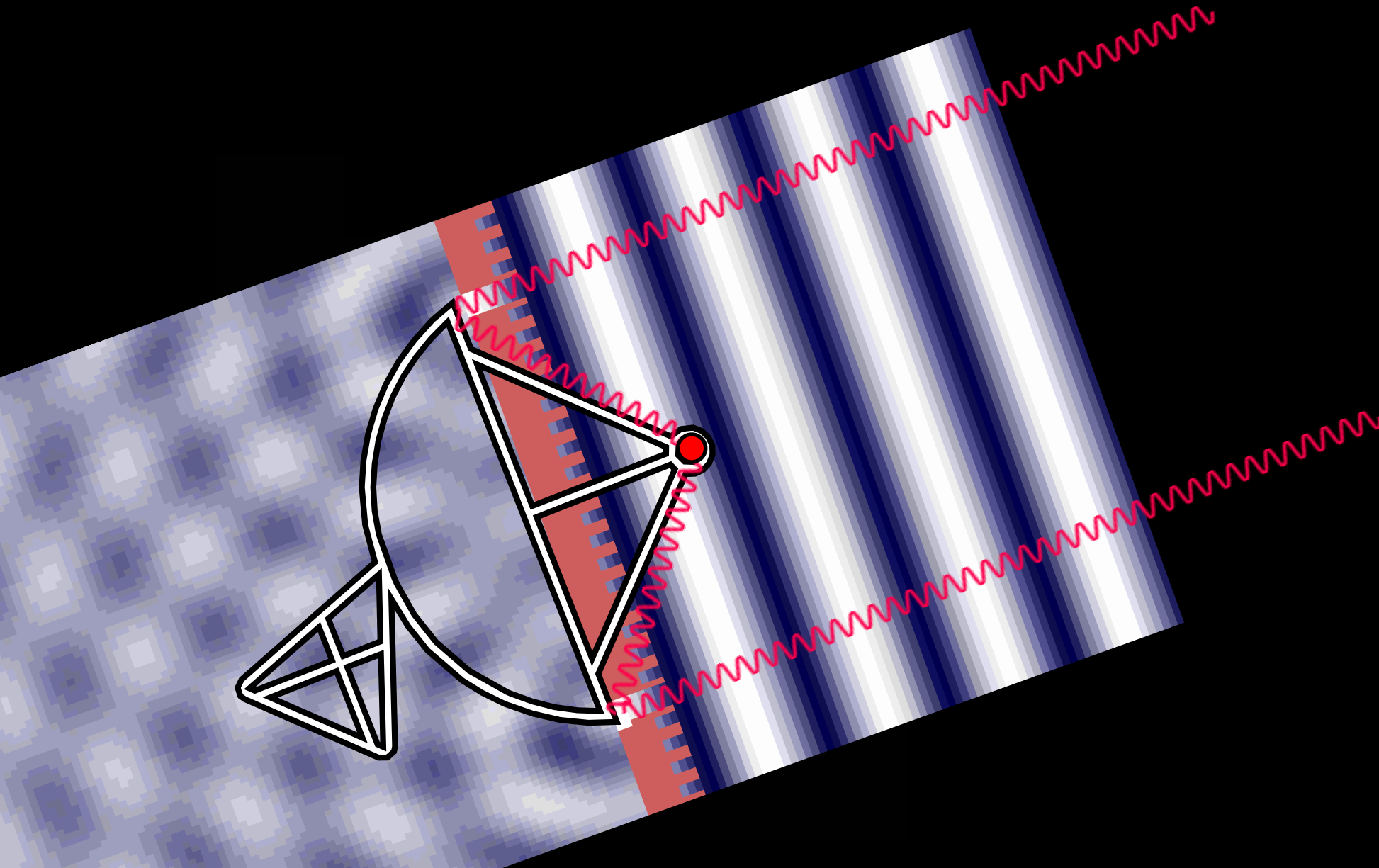


VLA (NRAO)

LOFAR (de Gasperin et al. 2012) VLT (ESO)

Event Horizon Telescope (EHT)

VLBI (very long baseline interferometry) principle



Mexiko



Hawaii



Südpol



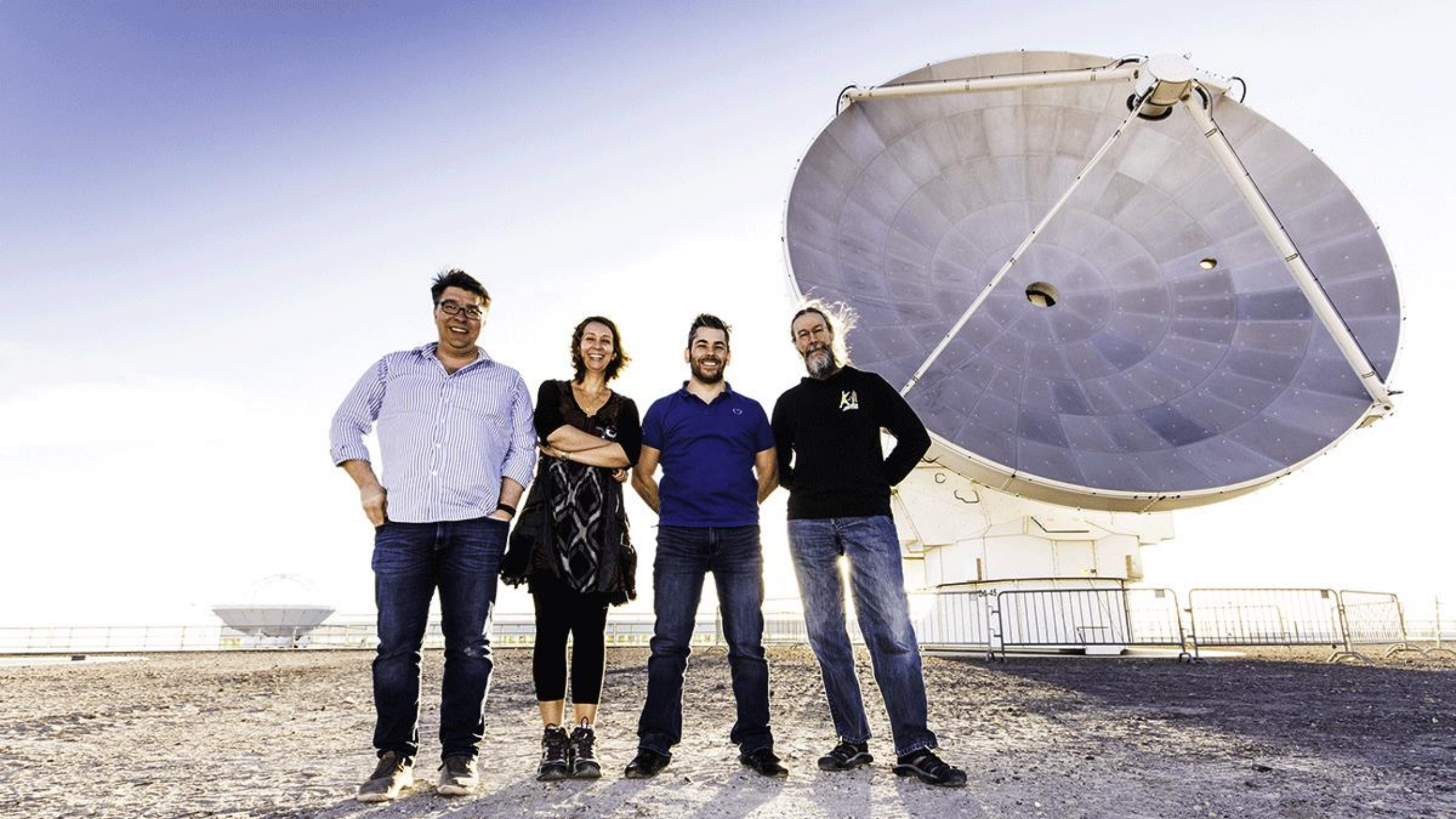
Chile



Arizona

Spanien







Espuma

APP

PISCO

División Emergencia

www.pisco.cl

Polvo Químico Seco



Nimwegen, Nov. 2018 – EHT Kollaborationstreffen



Radboud Universiteit







Images: LOFAR, VLT, HST,
VLBA, GMVA, EHT
© ESO (Music: N. Falcke)



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Nachrichten > Wissenschaft > Weltall > Schwarze Löcher > Schwarze Löcher: "Antworten zu den ganz großen Fragen des Lebens"

Forscher über schwarzes Loch

"Antworten zu den ganz großen Fragen des Lebens"

Das erste Foto eines schwarzen Lochs ist eine Sensation - was folgt jetzt? Der Initiator des Forschungsprojekts über hohe Adrenalinpegel, den Blick auf unsere Milchstraße und seinen Glauben an Gott.



Von *Jörg Römer* ▾

AAAS
Science **2019**



Einstein Medal 2020

RIJKS MUSEUM

www.rijksmuseum.nl
+31 (0)20 6747 000

Museumstraat 1
Postbus 74888
1070 DN Amsterdam
Nederland

Amsterdam, 12 december 2019

Betreft: Schenking

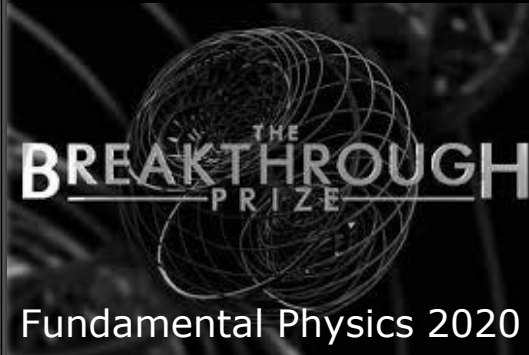
De heer H. Falcke
Leijendaalseweg 135
6525 AJ Nijmegen

Geachte heer Falcke,

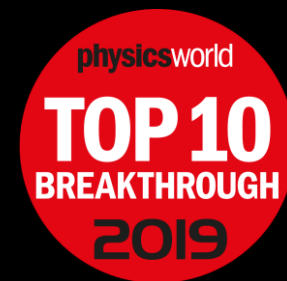
hartelijk dank voor het schenken van de foto getiteld 'Zwart gat in sterrenstelsel Messier 87 (M87)'. Dit is de allereerste foto die ooit van een zwart gat is gemaakt en is daarom van fotografisch en historisch belang. De foto vormt dan ook een mooie aanvulling op onze collectie. Wij zijn verheugd de foto te mogen opnemen in de collectie van het Rijksmuseum.

... and in some cases as big as our Solar System, black holes hide in the shadow of their gravity on objects around them and, lately, the gravitational waves they collide reveal their presence. But no one had ever seen one before. That's when an international team of radio astronomers released a dramatic image of a black hole's "shadow," showing a dark heart surrounded by a ring of photons zipping around it. Heino Falcke of Radboud University in Nijmegen, Netherlands, a member of the team that produced the image, said the first image was "looking at the gates of hell." That evocative image is *Science's* 2019

Breakthrough of the Year. [Read more ...](#)



Fundamental Physics 2020



Optical light



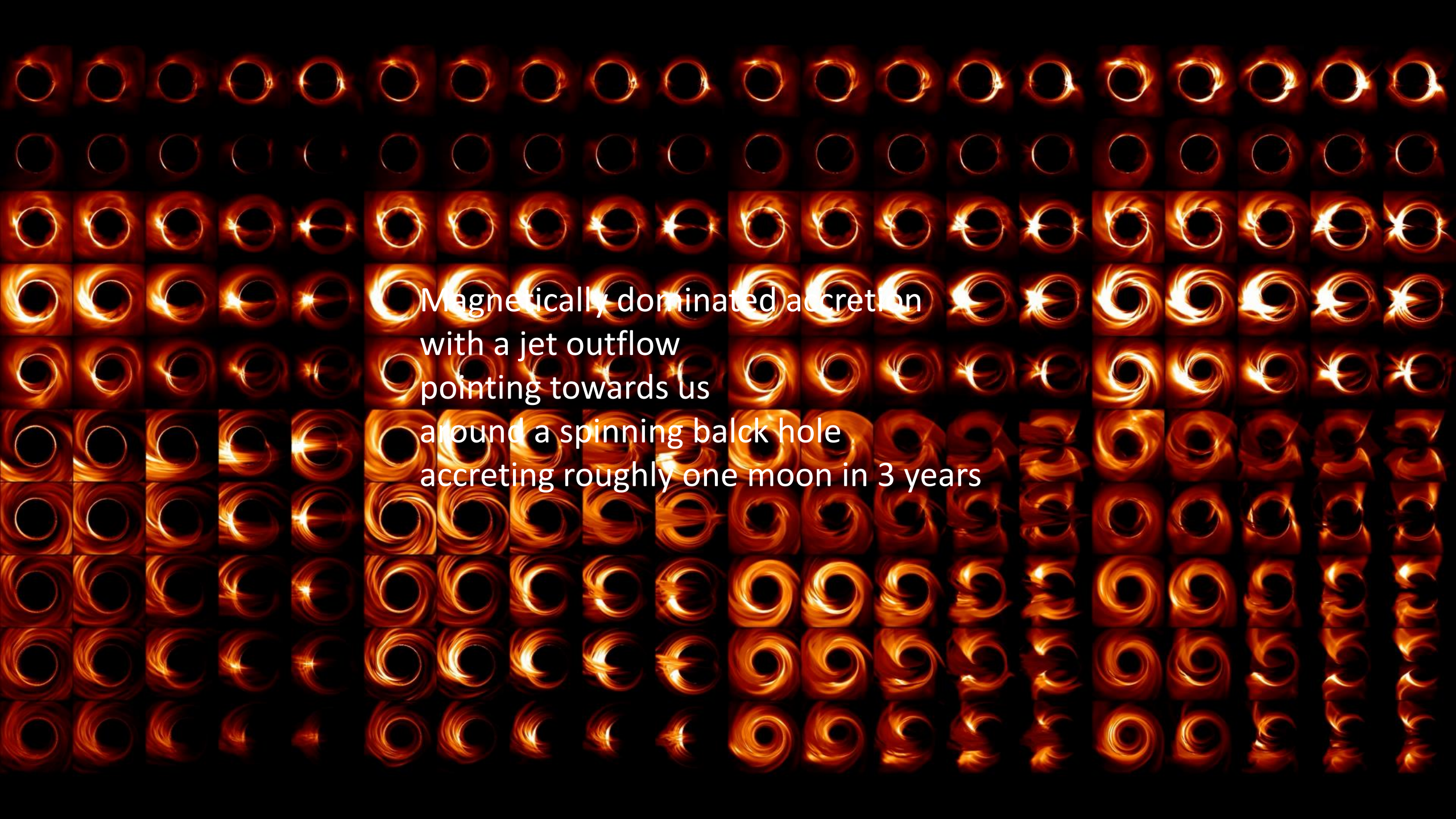


MAD

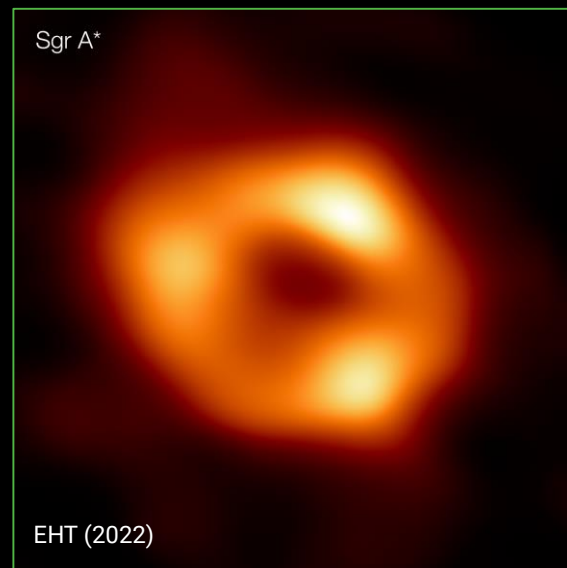
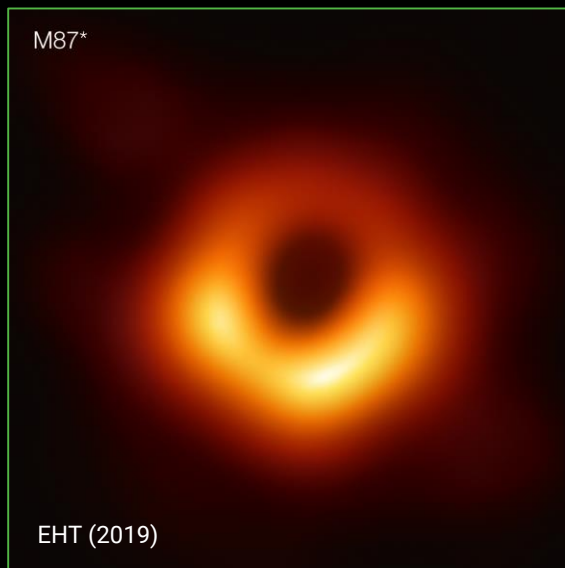
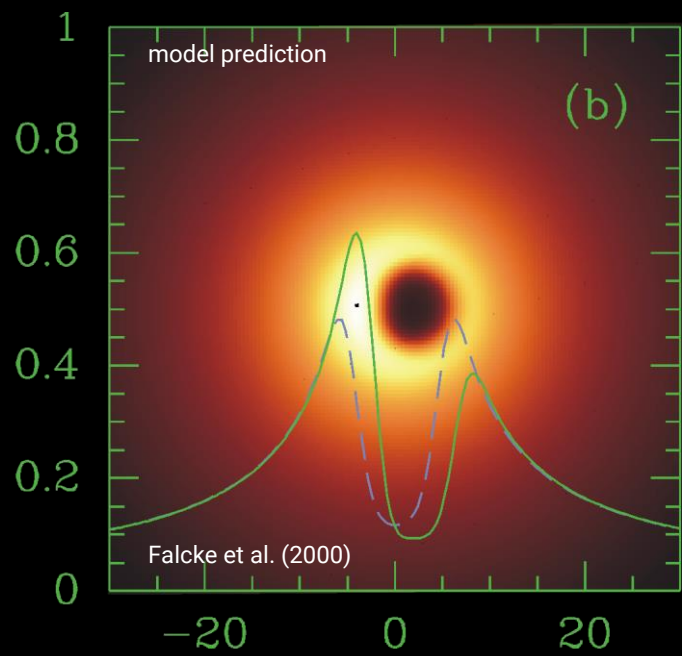
$$R_{\text{high}} = 160$$

$$a = +0.94$$

$$i = 90$$



Magnetically dominated accretion
with a jet outflow
pointing towards us
around a spinning black hole
accreting roughly one moon in 3 years

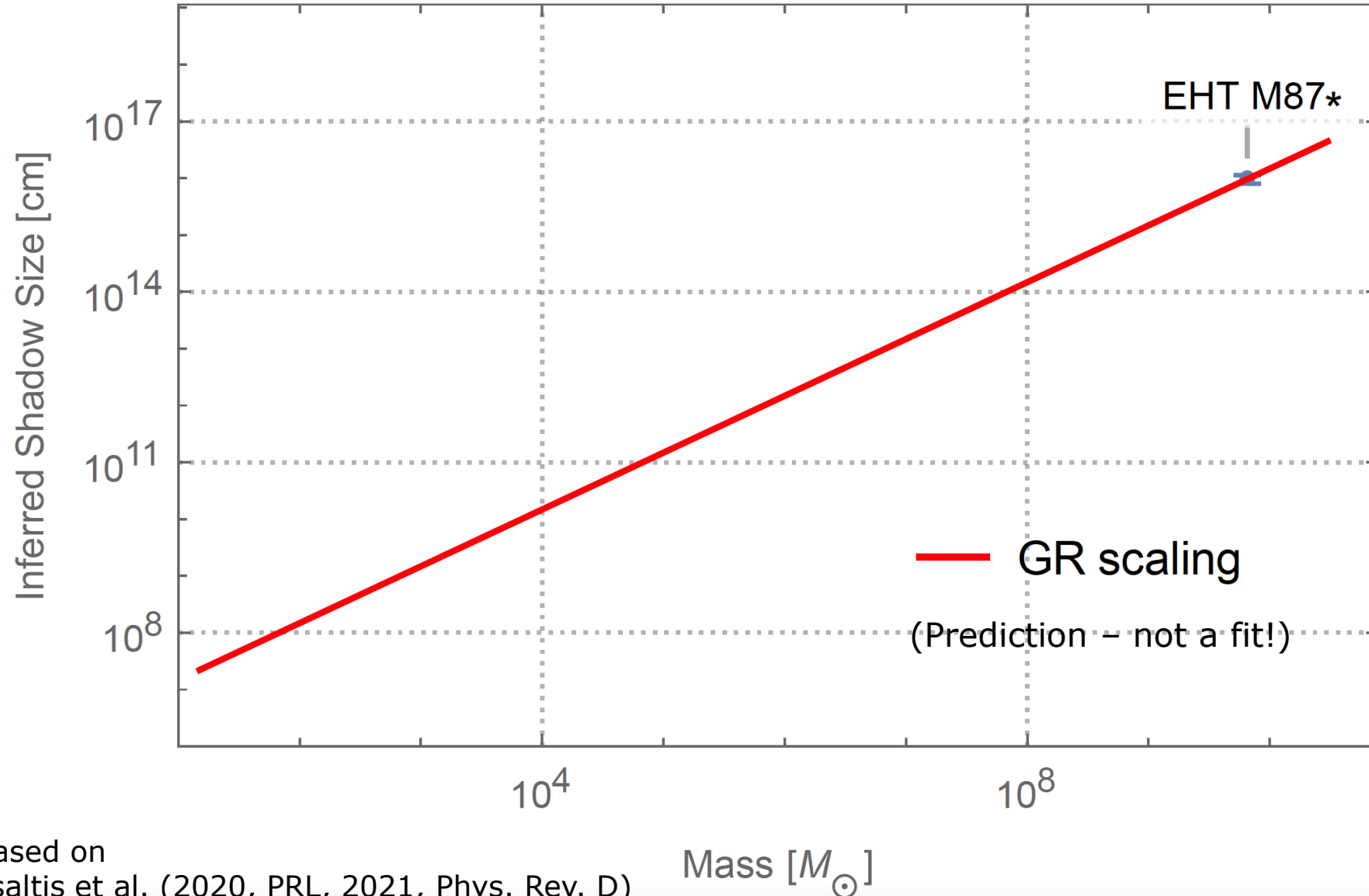


All you need to know is mass ...



Radboud University Nijmegen

Testing the scale invariance of general relativity over 8 orders of magnitude.



Based on
Psaltis et al. (2020, PRL, 2021, Phys. Rev. D)

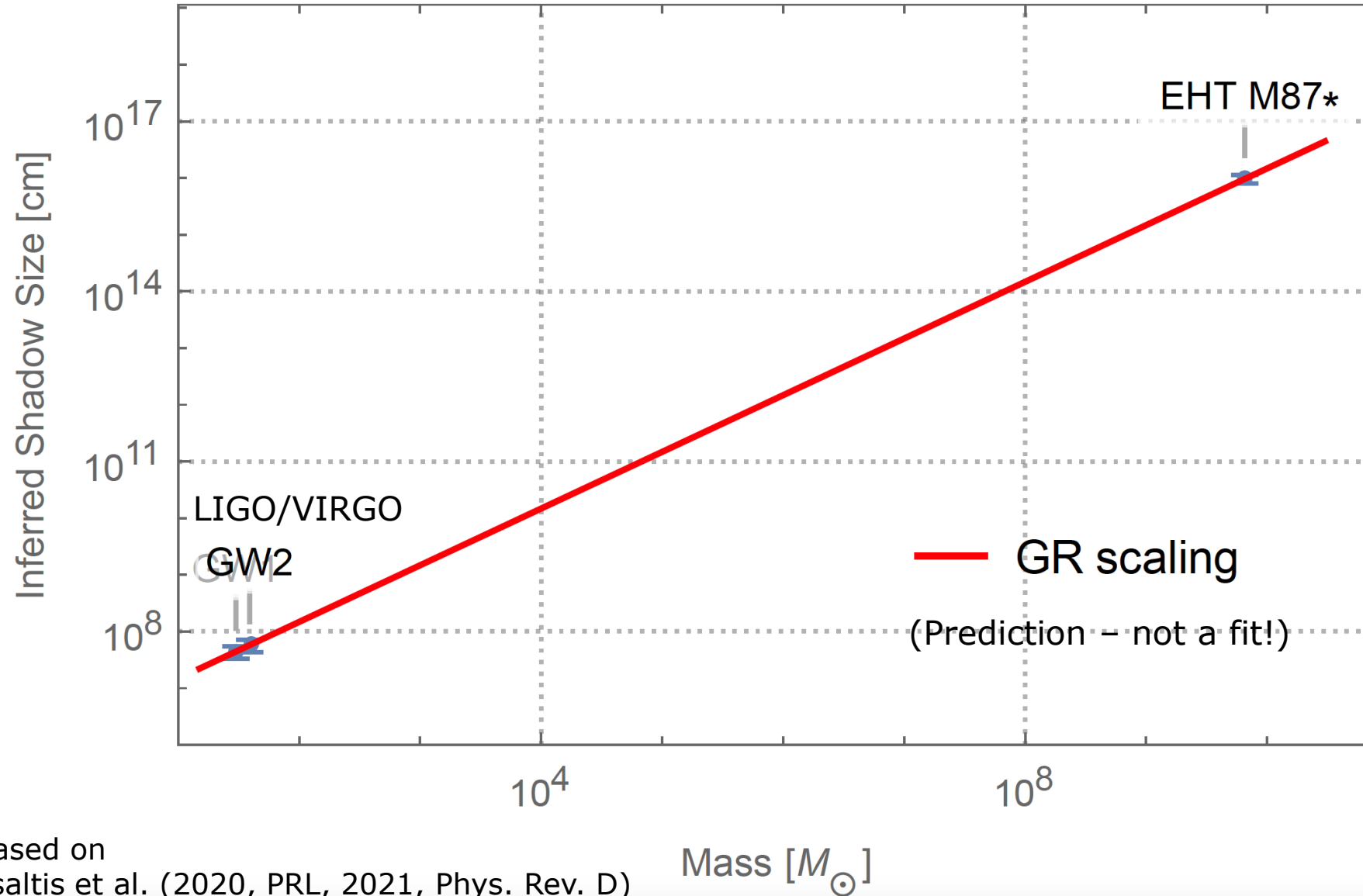
Mass [M_{\odot}]

All you need to know is mass ...



Radboud University Nijmegen

Testing the scale invariance of general relativity over 8 orders of magnitude.



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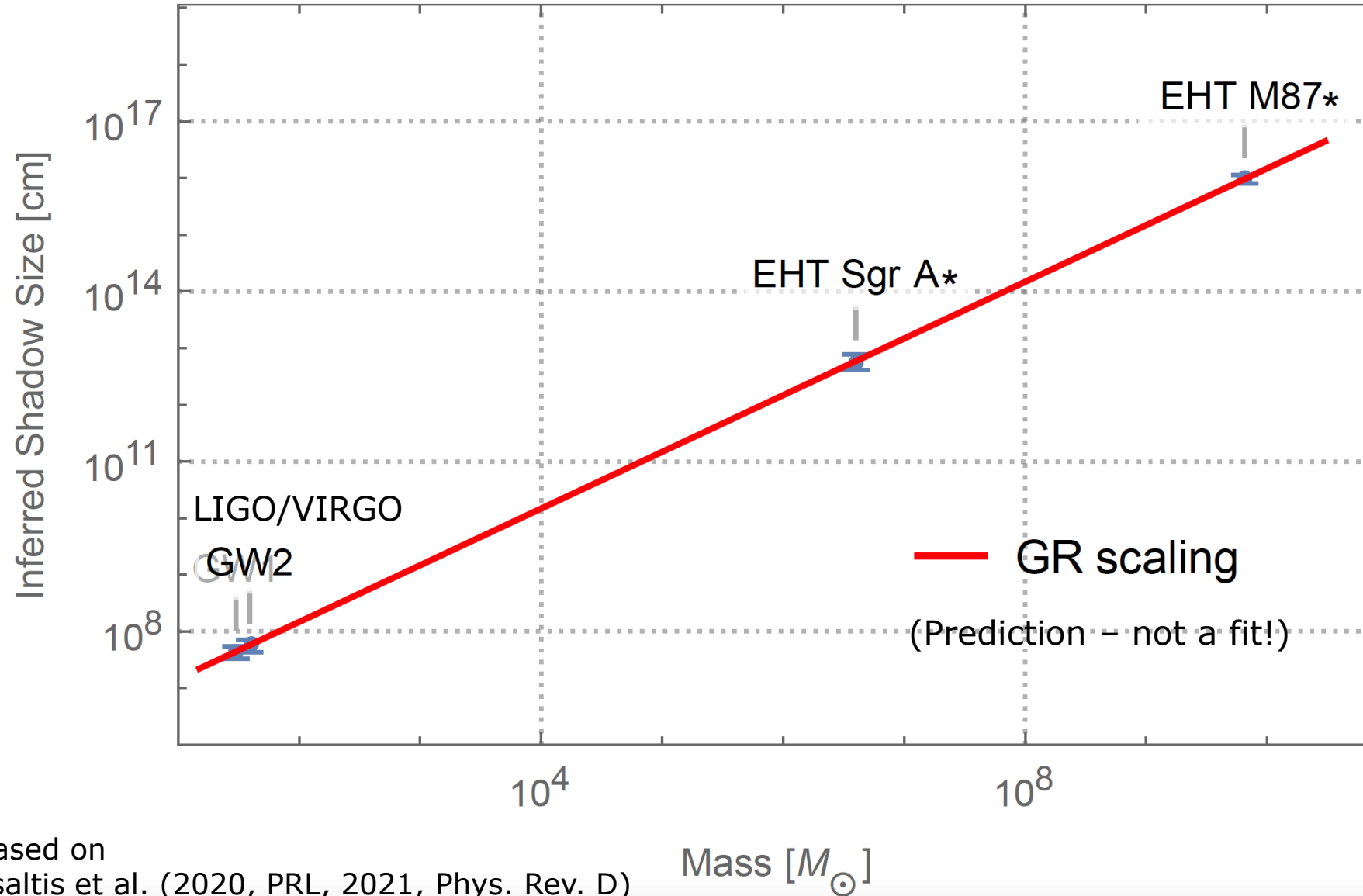
Mass [M_{\odot}]

All you need to know is mass ...



Radboud University Nijmegen

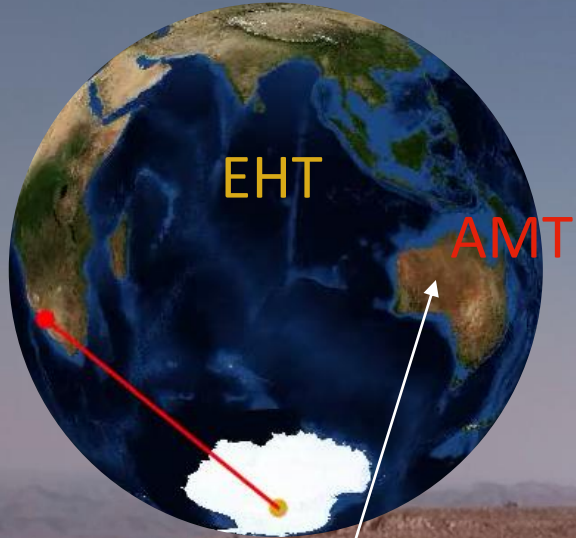
Testing the scale invariance of general relativity over 8 orders of magnitude.



Based on
Psaltis et al. (2020, PRL, 2021, Phys. Rev. D)

Mass [M_{\odot}]

Africa mm-wave Telescope (AMT): Expanding the Event Horizon Telescope to make movies



idealized input model
Supermassive black hole

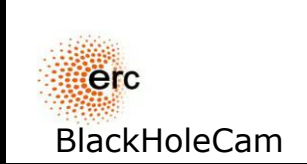
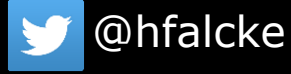


simulated observation
(EHT + AMT)



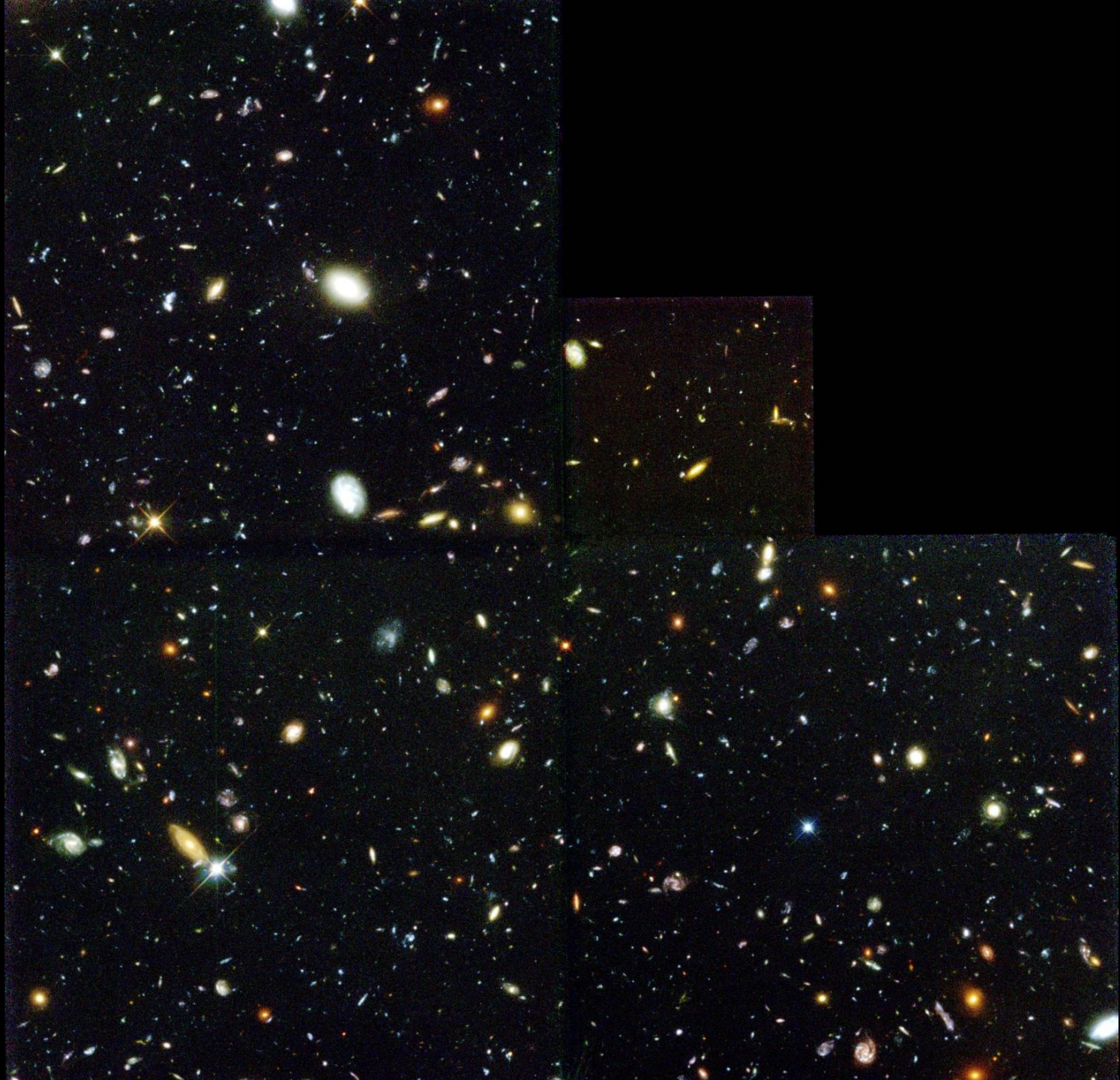
Proposed AMT site: Gamsberg table mountain (Namibia)

Conclusion



Radboud University BlackHoleCam

- EHT has seen a BH shadow twice now.
 - ⇒ Supermassive black holes are real
 - ⇒ Within GR the shadow is signature of light bending in Kerr metric and absorption by event horizon
 - ⇒ GW+EHT: GR holds over 8 orders of magnitude
- Astrophysics: Accretion is magnetically dominated, produce powerful jets (also in Sgr A*), also extract energy from BH spin (BZ effect), face-on
- Future: 11 telescopes + N (Africa,...), eventually Space
 - ⇒ Better images, higher frequency, multi-wavelength input, movies, dynamics, direct view into astrophysics of black holes, % level constraints on GR
- Age of experimental spacetime physics is here!



Hubble Deep Field
(STScI/NASA)

In the beginning ...

Genesis 1:1

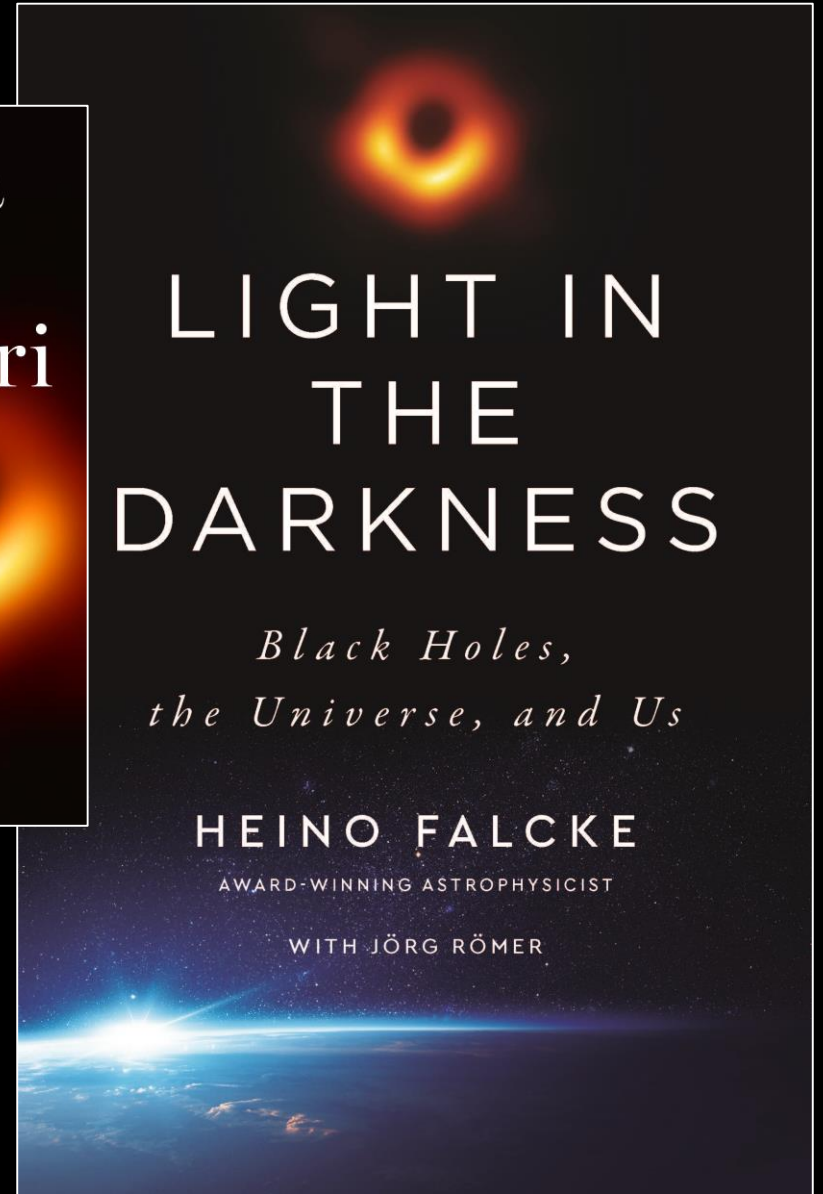


Space

Time

13,8 Milliarden Jahre

Light-in-the-darkness.org
Licht-im-Dunkeln.de



@hfalcke www.heinofalcke.org