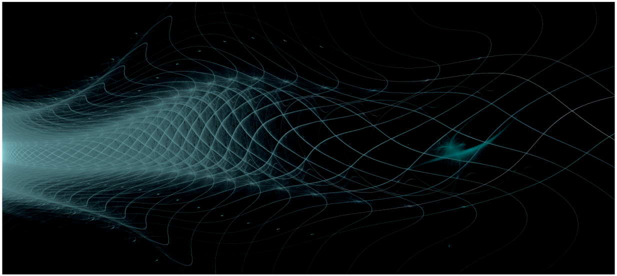
GRAVITY prospects for GR physics



Odele Straub

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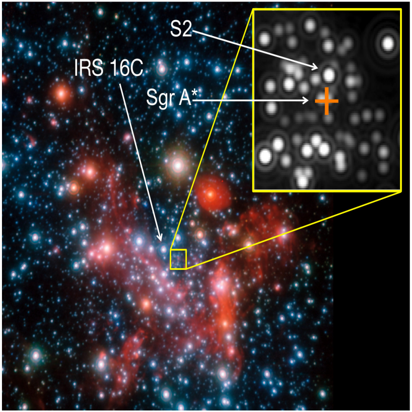
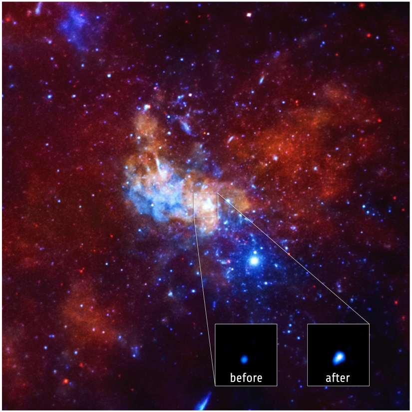
How is GRAVITY doing GR physics?

(ESO/MPE/Gillessen et al)

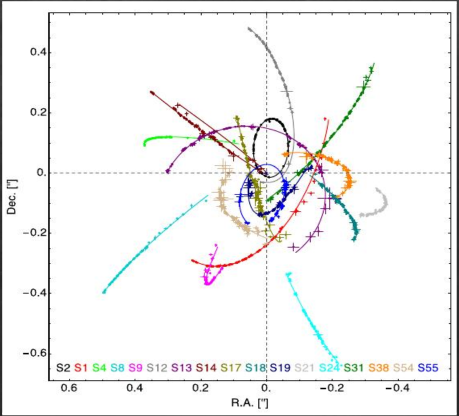


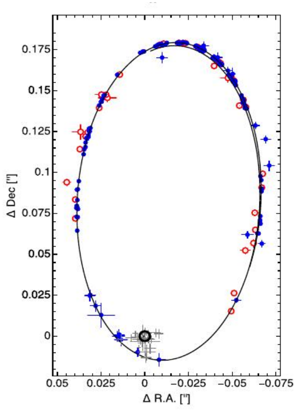
(NASA/CXC/Amherst College/Haggard et al)



- ⋆ Sgr A* is the biggest BH in the sky (d $\approx 53\mu$as for $a_* = 0$).
- ⋆ GRAVITY performs μas-astrometry on nearby stars and flares.

Stellar orbits 1: the S2 star



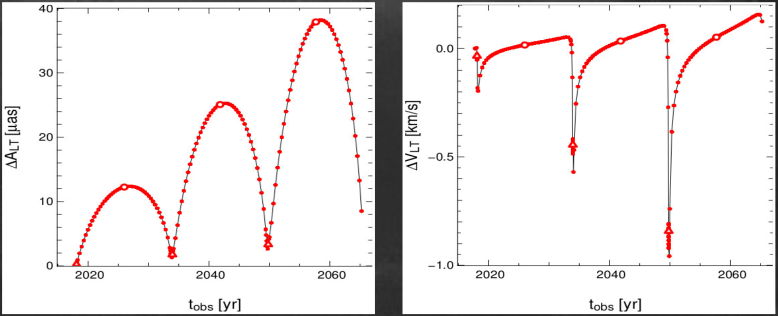


(Gillessen et al, 2017)

- ⋆ S2 star: shortest period (16y), second closest ($R_{peri} \approx 2000$ R_S = 17 lh, where v = 0.025 c)
- ⋆ Current data consistent with Keplerian orbit
- ⋆ Next pericenter passage in 2018!

Stellar orbits 2: GR with S2

(Grould et al, in prep)

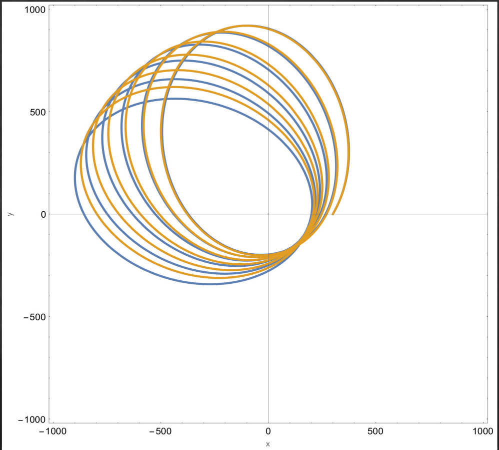


The combination of astrometric (left) and spectroscopic (right) observations (10 μas, 10 km/s accuracy) should allow to detect the transverse Doppler effect and gravitational redshift in *a few months*; higher-order relativistic effects (e.g. grav. lensing) in *a few years*

- ⋆ Δ = R_{peri}, $\circ$ = R_{apo}
- ⋆ simulated data for $a_* = 0.99$ and 2 periods of monitoring $\rightarrow$ best fit constrains spin: $0.8 < a_* < 1$

Stellar orbits 3: constrain the BH mass

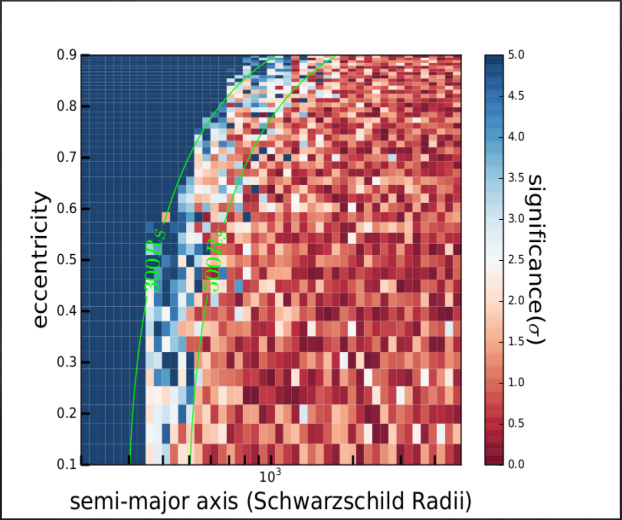
(Straub et al in prep)



- ⋆ Schwarzschild BH → prograde orbits (blue)
- ⋆ Schwarzschild BH with extended mass distribution (1% of $M_{Sgr A*}$ is dark mass) → retrograde orbits (orange)
- ⋆ allows to constrain the mass distribution

Stellar orbits 4: constrain the BH spin

(Waisberg, Dexter et al. in prep)



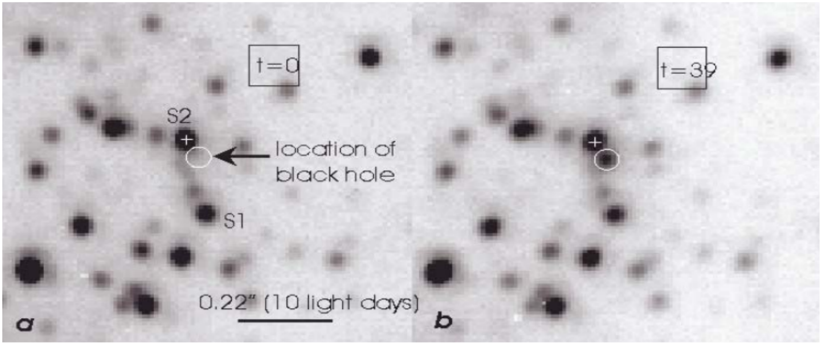
Required eccentricities to measure the BH spin for a typical observing campaign of 4 years with 10 μas astrometric error.

sma = R_{peri}

σ: best-fit for $a_* = 0.9$

Sgr A* flares 1

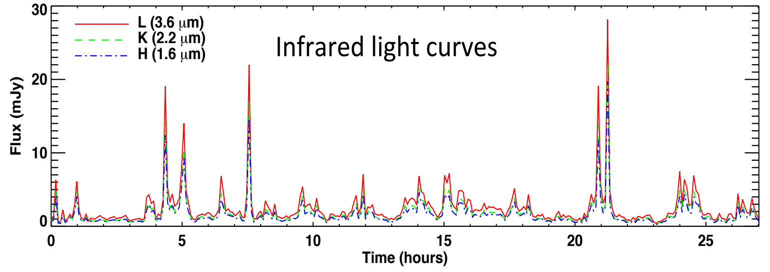
(Genzel et al, 2003)

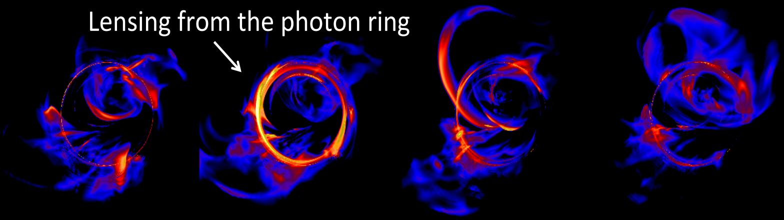


- ⋆ Flares are recurrent bursts of radiations in the IR & X-ray
- ⋆ models: inefficient flow with hot spot, jet, red noise...
- ⋆ Why is this interesting? - variability (ca 20-40min) corresponds to near ISCO radius, i.e. the strong gravity regime

Sgr A* flares from shock heating

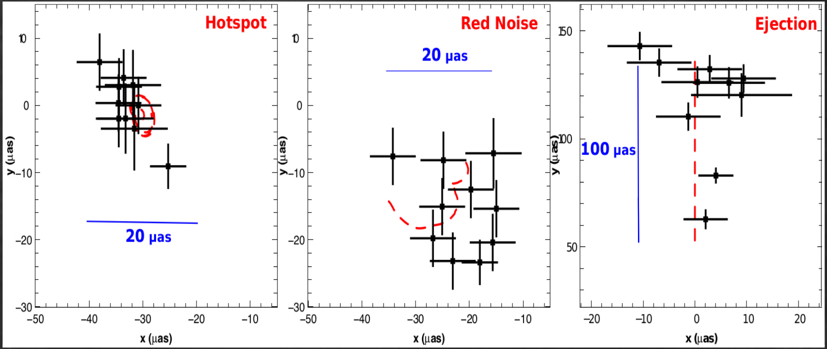
Dexter & Fragile (2013)





Sgr A* flares 3: centroid tracks

(GRAVITY simulation by Vincent et al. 2014)



- ⋆ Flares: Hot spot, red noise, or jet?
- ⋆ GRAVITY can distinguish between the models if $t_{flare} \geq 1.5$h
- ⋆ Some flares models allow to constrain the BH spin and inclination

GRAVITY prospects for GR physics - Things to take home

- stellar orbits around Sgr A*: GRAVITY is capable of finding deviations from Keplerian orbits, it can distinguish between a non-rotating and a rotating BH within a few months of observation, it can put constraints on the BH mass and the BH spin

- flares from Sgr A*: GRAVITY is capable of distinguishing between different flare models, from the best fitting model it can constrain the BH spin and inclination

Acknowledgements

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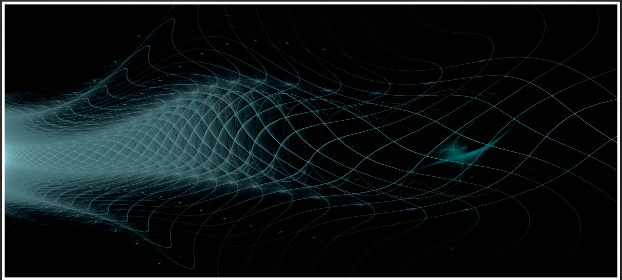
- MPE - Jason Dexter, Frank Eisenhauer, Reinhard Genzel, Stefan Gillessen, Oliver Pfuhl, Idel Waisberg
- Uni Köln - Andreas Eckart, Christian Straubmeier

Institutes:

The end



(Artwork: Tom Allen @ Fractamonium/Deviantart)