

Massive Black Holes & the Evolution of Galaxies

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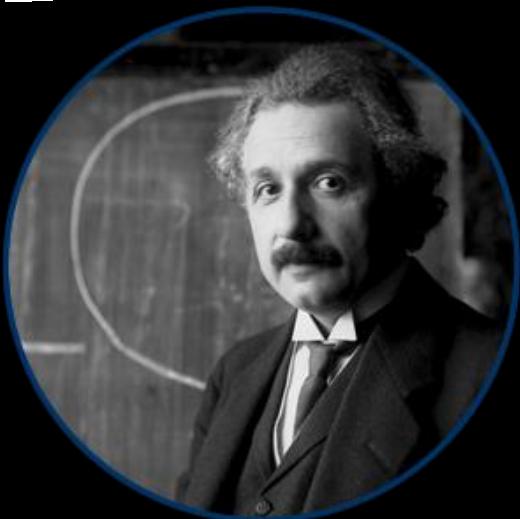
1916.

Nº 7.

ANNALEN DER PHYSIK.
VIERTE FOLGE. BAND 49.

1. Die Grundlage
der allgemeinen Relativitätstheorie;
von A. Einstein.

Die im nachfolgenden dargelegte Theorie bildet die denkbar weitgehendste Verallgemeinerung der heute allgemein als „Relativitätstheorie“ bezeichneten Theorie; die letztere nenne ich im folgenden zur Unterscheidung von der ersten „spezielle Relativitätstheorie“ und setze sie als bekannt voraus. Die



A Century of General Relativity

Über das Gravitationsfeld eines Massenpunktes
nach der EINSTEINSchen Theorie.

Von K. SCHWARZSCHILD.

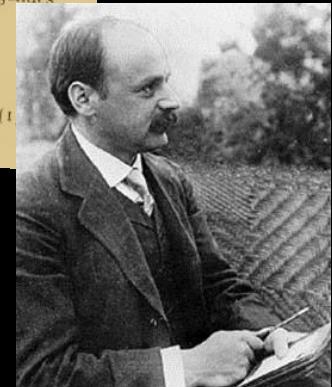
(Vorgelegt am 13. Januar 1916 [s. oben S. 42].)

§ 1. Hr. EINSTEIN hat in seiner Arbeit über die Perihelbewegung des Merkur (s. Sitzungsberichte vom 18. November 1915) folgendes Problem gestellt:

Ein Punkt bewege sich gemäß der Forderung

wobei

$$\delta \int ds = 0, \\ ds = \sqrt{\sum g_{uv} dx_u dx_v} \quad u, v = 1, 2, 3, 4 \quad (1)$$



GRAVITATIONAL FIELD OF A SPINNING MASS AS AN EXAMPLE
OF ALGEBRAICALLY SPECIAL METRICS

Roy P. Kerr*

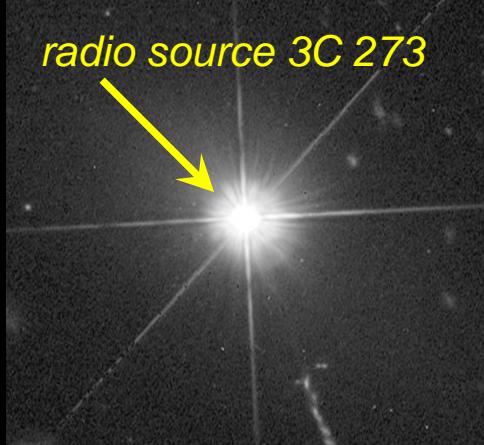
University of Texas, Austin, Texas and Aerospace Research Laboratories, Wright-Patterson Air Force Base, Ohio
(Received 26 July 1963)

Goldberg and Sachs¹ have proved that the algebraically special solutions of Einstein's empty-space field equations are characterized by the existence of a geodesic and shear-free ray congruence, k_μ . Among these spaces are the plane-fronted waves and the Robinson-Trautman metrics² for which the congruence has nonvanishing divergence, but is hypersurface orthogonal.

where ξ is a complex coordinate, a dot denotes differentiation with respect to u , and the operator D is defined by

$$D = \partial/\partial\xi - \Omega\partial/\partial u.$$

P is real, whereas Ω and m (which is defined to be $m_1 + im_2$) are complex. They are all independent of the coordinate r . Δ is defined by

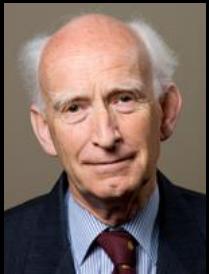


The Discovery of Quasars



Marten Schmidt
1963

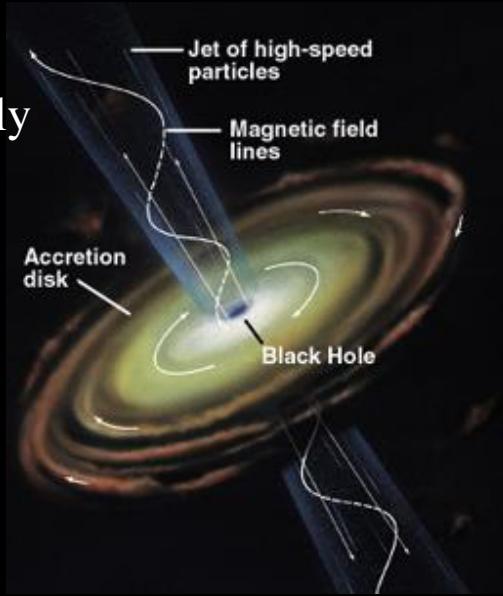
$z=0.16$, $D_L \sim 2.4 \times 10^9$ ly
 $L \sim 10^3 L_{MW}$



D. Lynden-Bell



M. Rees



R. Sunyaev



E. Salpeter

'massive black hole paradigm'

$E < 0.4 Mc^2$
variable X- und γ -radiation
relativistic radio jets

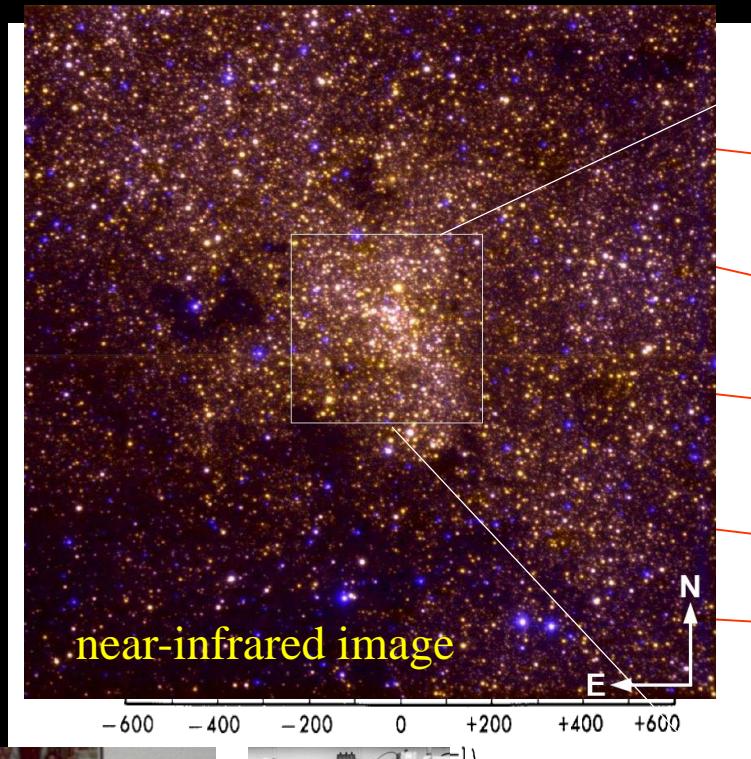
ON QUASARS, DUST AND THE GALACTIC CENTRE

D. Lynden-Bell and M. J. Rees

(Received 1971 January 5)

following Lynden Bell & Rees 1971:

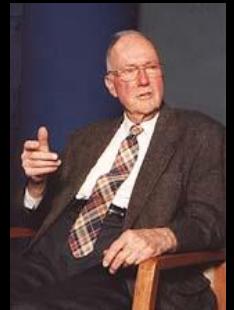
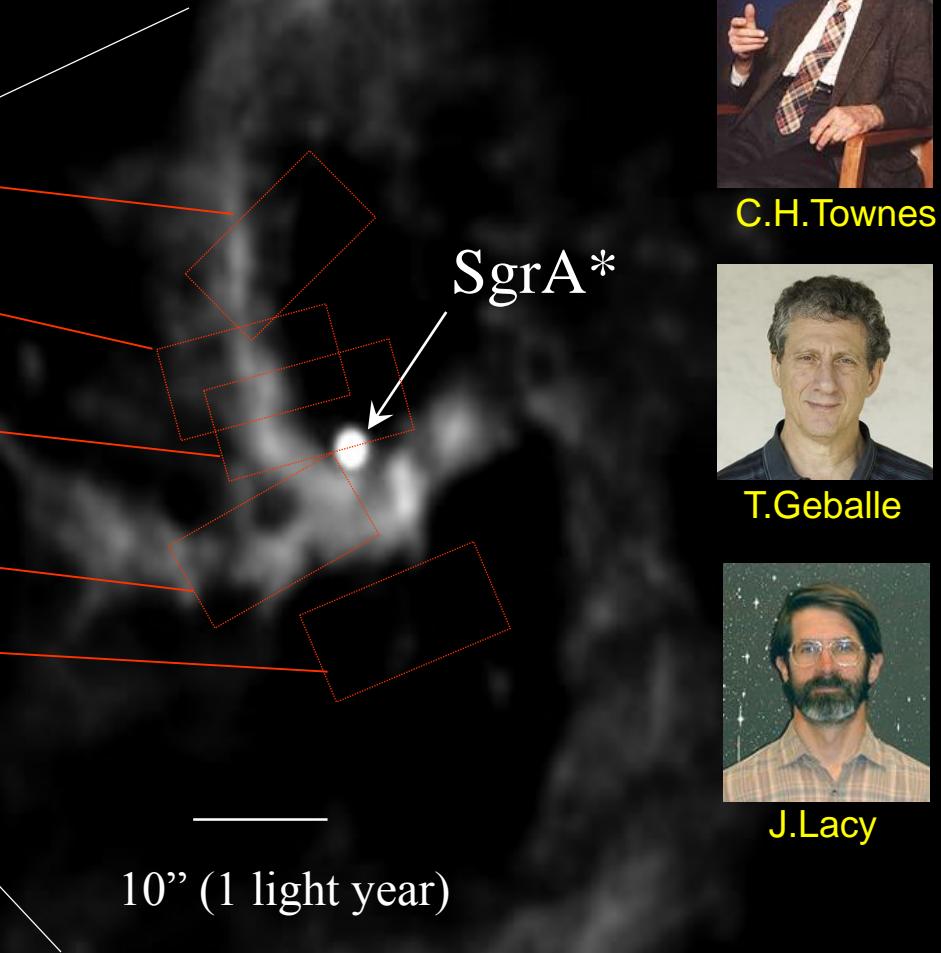
Early Evidence for a mass concentration in the Galactic Center



E. Becklin



G. Neugebauer



C.H.Townes



T.Geballe



J.Lacy

Becklin et al. 1971, Balick & Brown 1974, Lo et al. 1975, Wollman et al. 1977, Lacy et al. 1980, 1982

A Quest of 25 years

The ESO Very Large Telescope



NACO



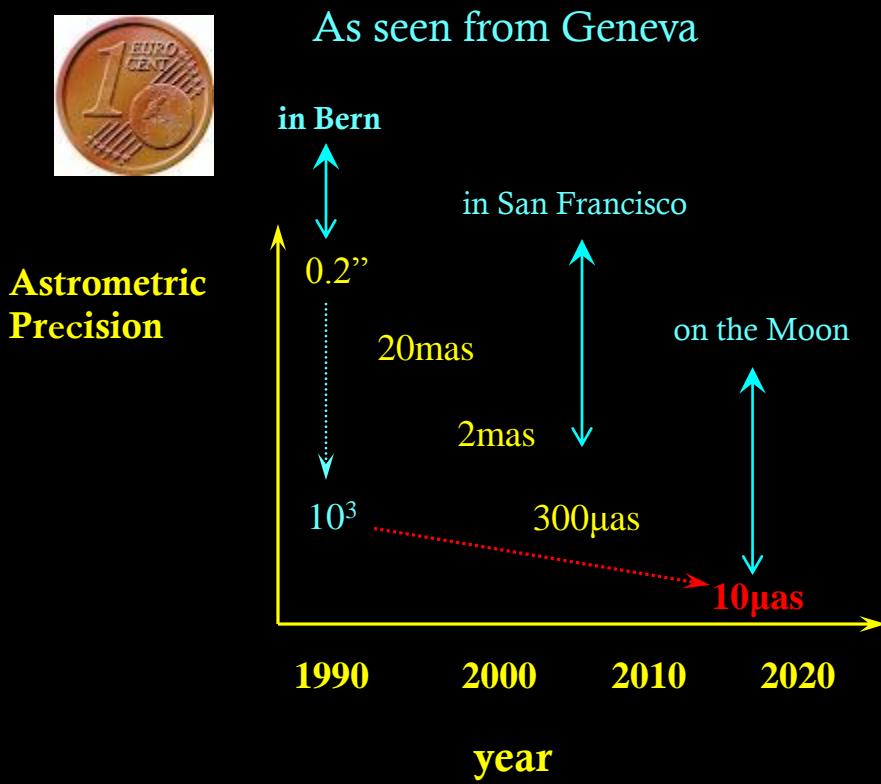
SINFONI



Laser



GRAVITY



F.Eisenhauer



S.Gillessen



A.Eckart



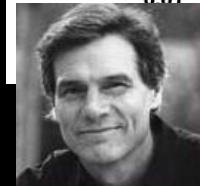
R.Schoedel



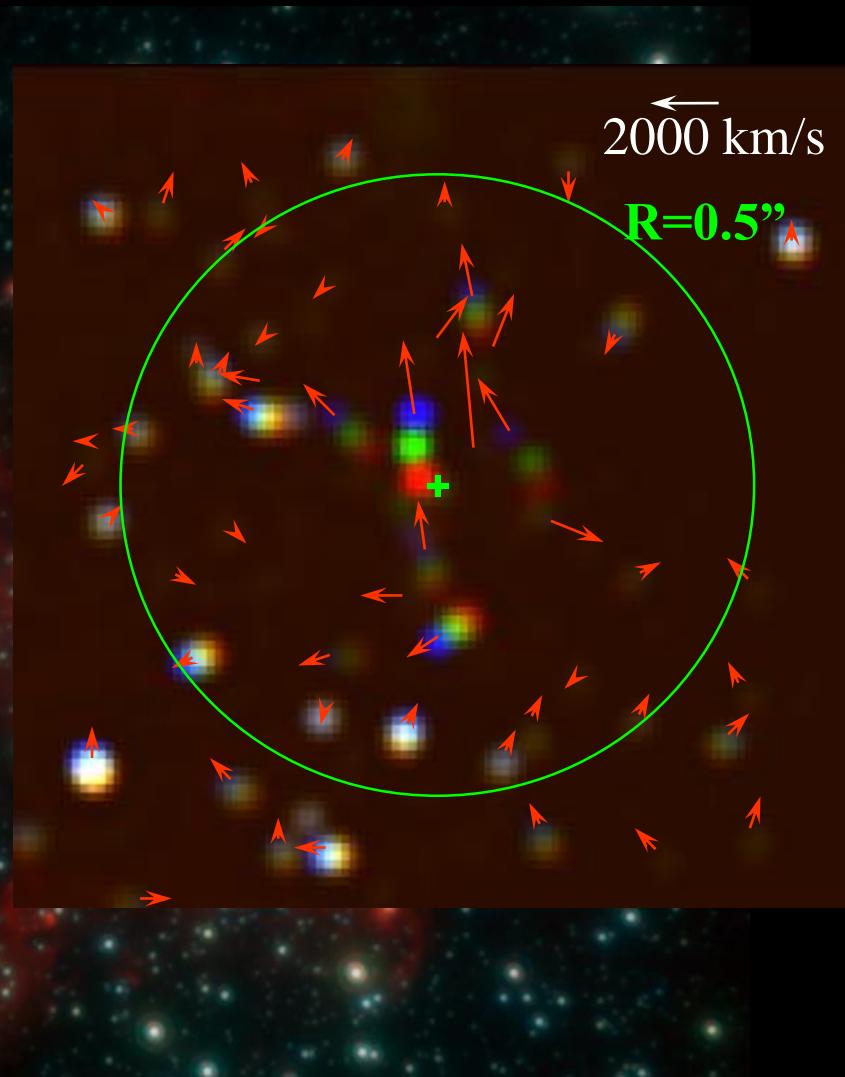
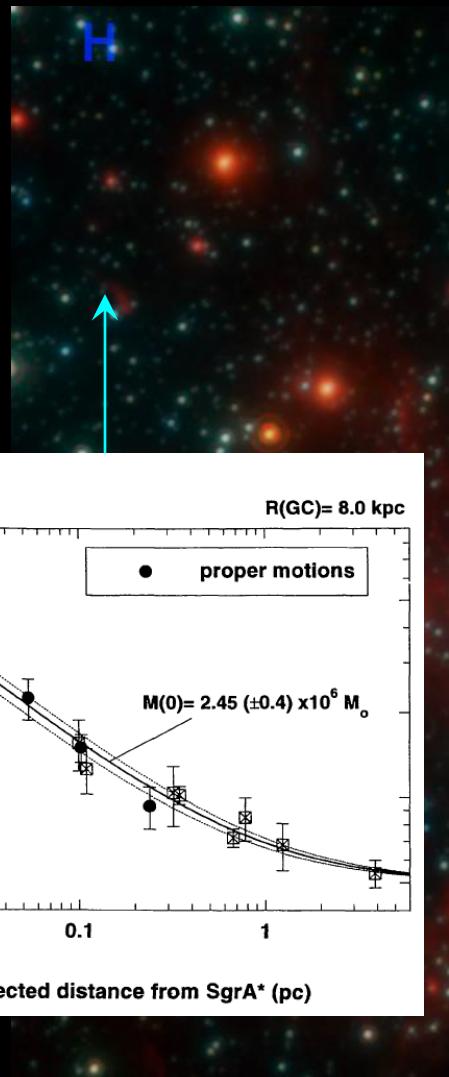
A.Ghez



M.Morris

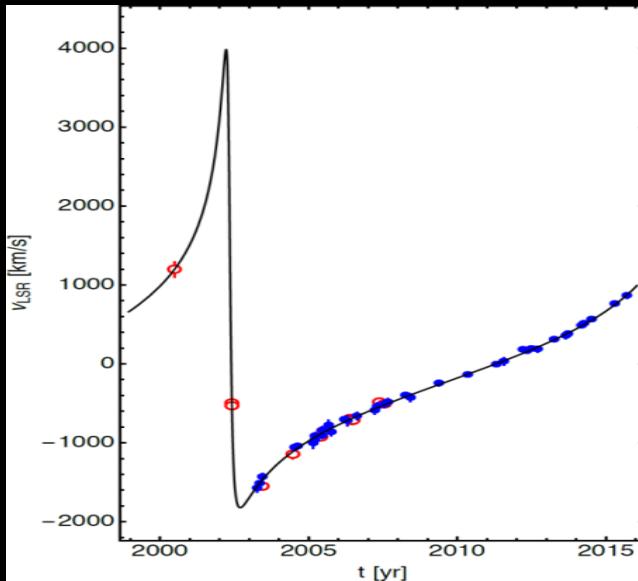
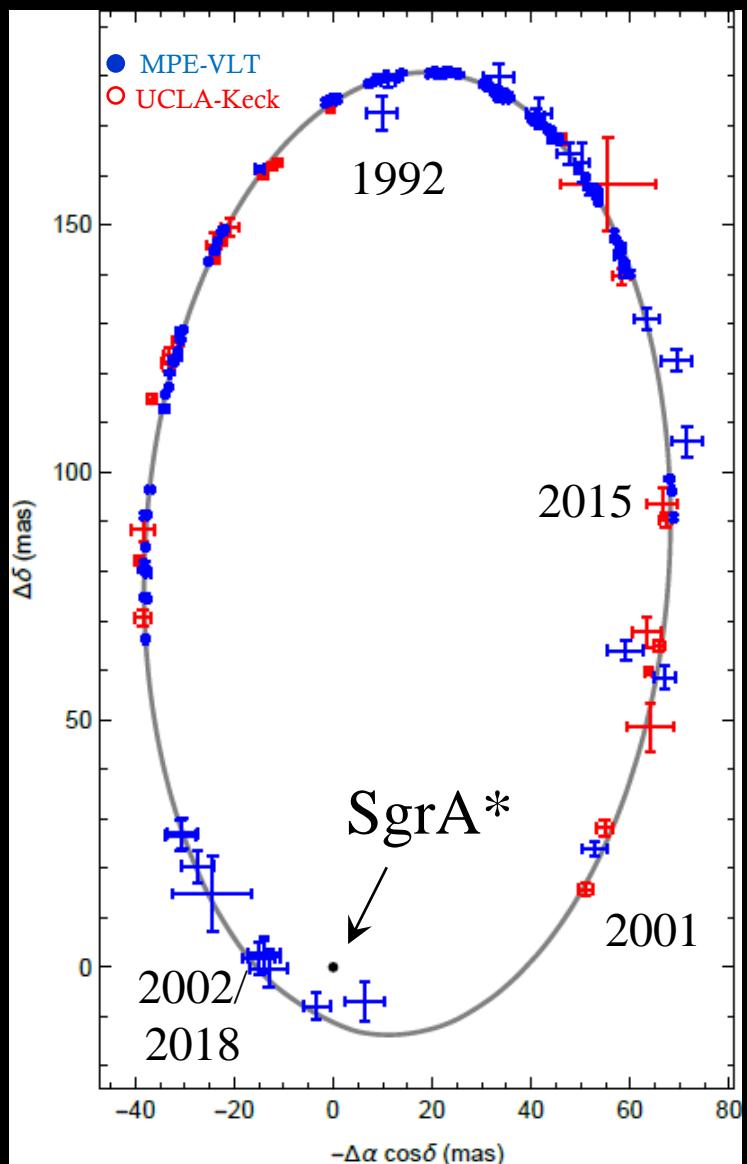


Motions of stars around SgrA*



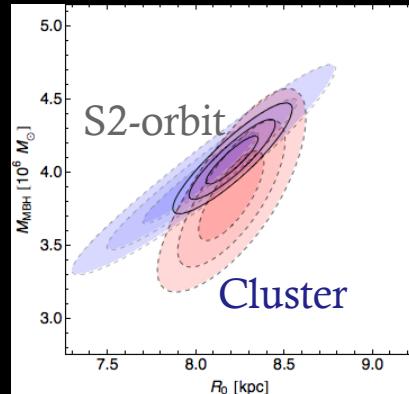
Eckart & Genzel 1996, 1997, Ghez et al. 1998

stellar orbits testing the potential: S2



S2/S02
 $P=15.9$ y
 $R_{\text{peri}}=1400 R_S$
(17 lh)
 $\beta_{\text{peri}}=0.03$

$M_\bullet = 4.26(\pm 0.14)_{\text{stat}}(\pm 0.25)_{\text{sys}} \times 10^6 M_\odot$
 $R_0 = 8.36 (\pm 0.1)_{\text{stat}}(\pm 0.2)_{\text{sys}} \text{ kpc}$
 $\rho_\bullet > 10^{16..19.5} M_\odot \text{ pc}^{-3}$
 $M_{\text{extended}}/M_\bullet < \text{a few } 10^{-2}$
 $M_\bullet \text{ & } SgrA^* \text{ coincident } < 0.3 \text{ mas}$



Schödel et al. 2002, 2003, Ghez et al. 2003, 2008,
Eisenhauer et al. 2003, 2005, Gillessen et al. 2009a,b, Meyer
et al. 2012, Chatzopoulos et al. 2015, Fritz et al. 2015, Plewa
et al. 2015

