RVW

Does "Black hole" = Kerr metric ?

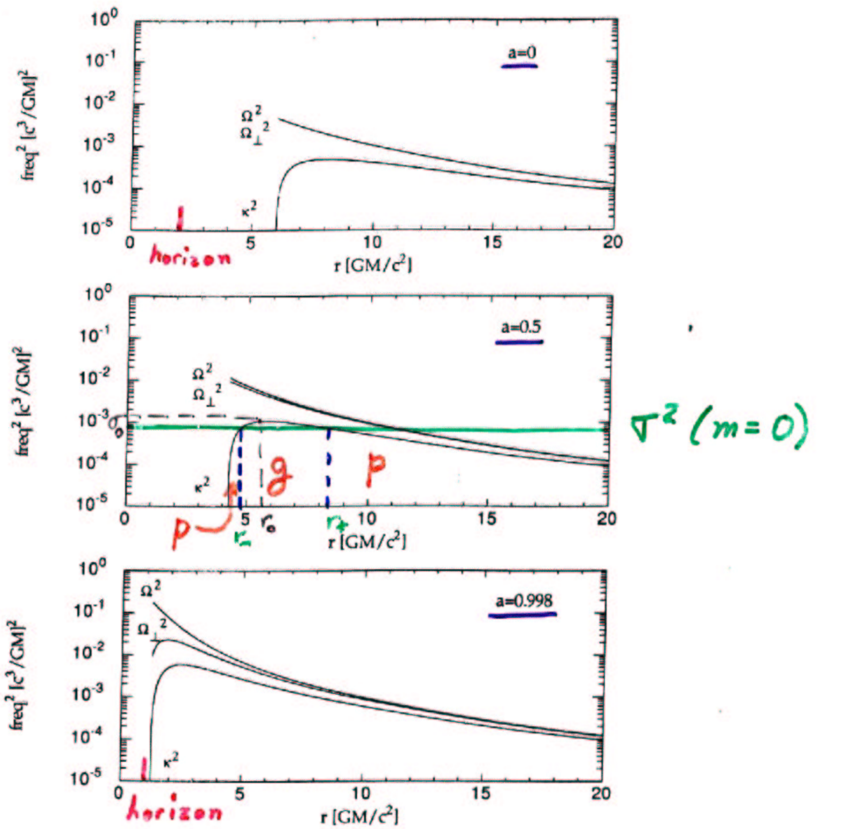
1) Inspiral of $m \ll M_{BH}$ (LISA, LIGO? VIRGO?)
- Effects of spin of m, accretion disk,...
- Model: perturbations of Kerr,...
- How many multipole moments?

2) QPOs
- "Equilibrium" model ?: Is $p \gg B^2/8\pi$? Effects of "corona",...
- GRS 1915+105 + others (Ron Remillard)
- Diskoseismology: predictions (RVW,...)
- Resonance models (Wlodek Kluzniak,...)
- Formation and survival of "blob"
- Compton microscope (Emrah Kalemci)
- Need for larger detectors

3) Line profiles
- Other explanations
- Observational prospects

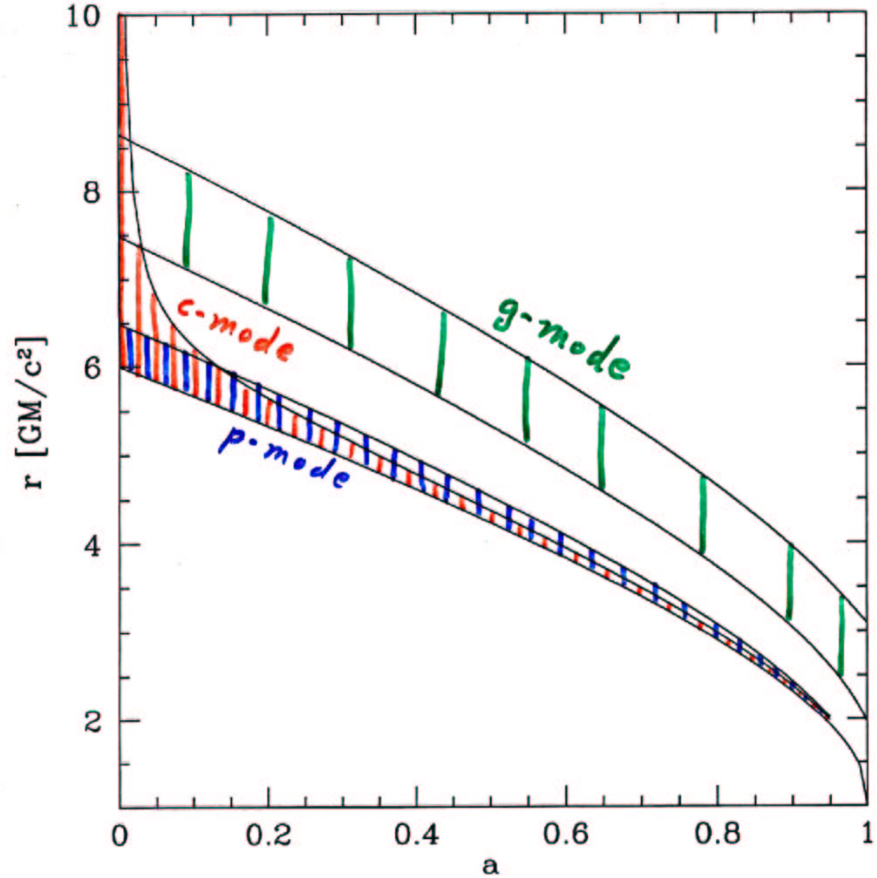
4) Evidence for event horizon
- Is $\dot{M} \ll \dot{M}_{ADAF} \sim \dot{M}_{Bondi} \sim \dot{M}_{in} \sim \dot{M}_{out}$?
- Prospects for measuring $\dot{M}$, $\dot{M}_{in}$, $\dot{M}_{out}$
- Gravitational self-lensing

5) BH-pulsar binary
- Inclination = 90° - ?
- Liklihood of discovery



Basis of relativistic diskoseismology

Fig. 1—The radial dependence of the square of the key frequencies characterizing the disk: Keplerian (Ω), and radial (κ) and vertical ($\Omega_\perp$) epicyclic. Three values of the black hole angular momentum parameter $a = cJ/GM^2$ are chosen.



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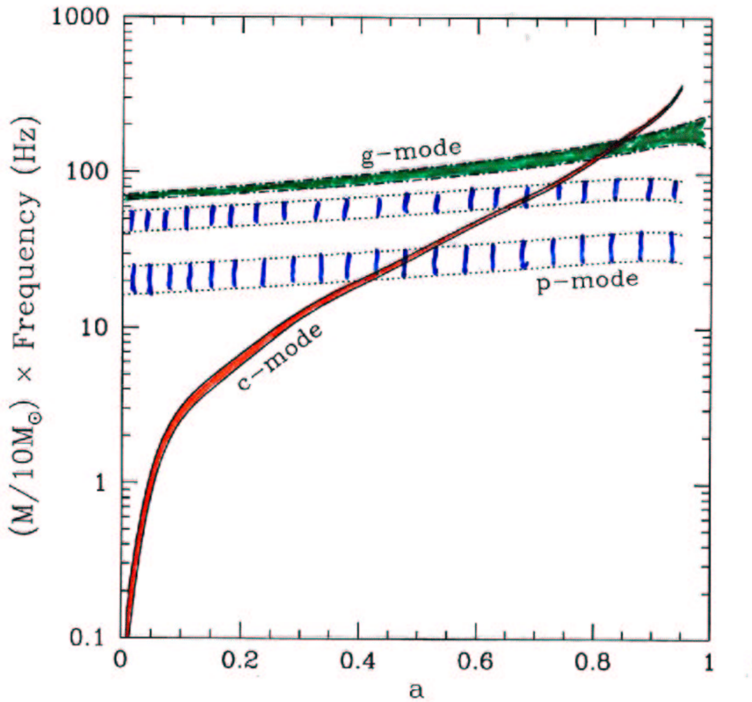


Fig. 1.— The dependence of the fundamental frequencies of the three diskoseismic modes on the angular momentum of the black hole. The spread of each corresponds to the range $0.01 \leq L/L_{Edd} \leq 1.0$, and is relatively insensitive to the choices $M/M_\odot \sim 10$ and $\alpha \sim 0.1$. The upper band for the p-mode corresponds to $\mu = 0$ with $\beta = 0.95$, and the lower band to $\mu = 2/5$ (no torque, $\beta = 1.00$).

Diskoseismology Predictions

Source	Frequency	Mode	a	$M/M_\odot$	$M_{obs}/M_\odot$
GRO J1655-40	449 Hz 295	c g	0.92	5.9±1.0	6.3±0.5 (a)
GRS 1915+105	68 42	g c	0.70	18.2±3.1	(≥) 14±4 (b)
XTE J1550-564	270-282 180-188 143 93 65	c g	0.92	9.6±1.6	10.0±1.5 (c)

a) Shabaz et al. 1999; Greene et al. 2001

b) Greiner 2002

c) Orosz et al. 2002

Dependence on Luminosity and Mode Number

g-mode $(m=0)$

$\sigma = \kappa_{max}[1-\epsilon_{jn}]$, $\quad \epsilon_{jn} \approx 0.1 \frac{(n+\frac{1}{2})}{(j+1)} \frac{L}{L_{Edd}}$

$d\log\sigma / d\log L \approx -\epsilon_{jn}$

c-mode $(j=m=1)$

$\sigma = \Omega(r_c) - \Omega_\perp(r_c) \approx \frac{2a}{r_c^3}$, $\quad \Delta r \propto (n+1)$

$d\log\sigma / d\log L = -(0.03-0.1)$

p-mode $(j=m=0)$

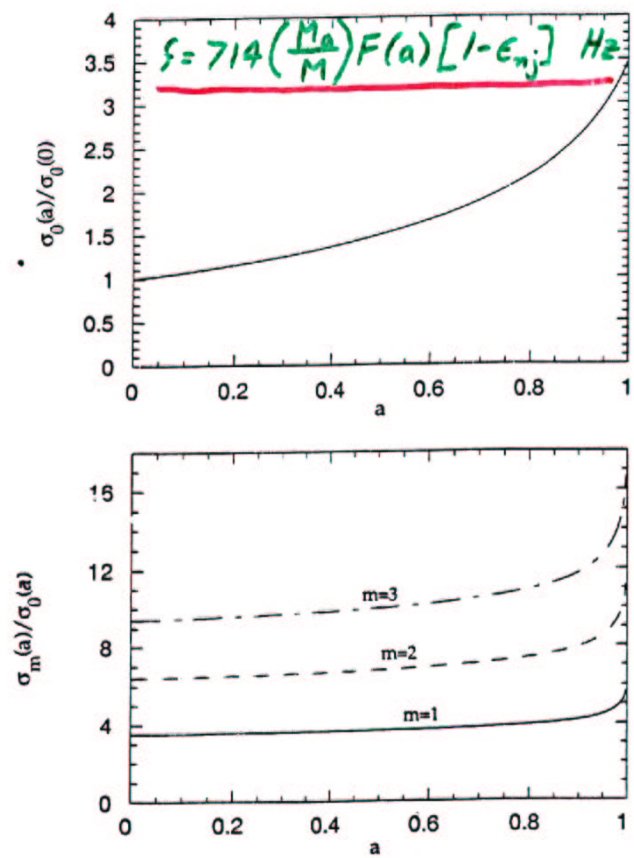
$\sigma \propto (2n+1)^{1/3} c_s^{1/3}$

$d\log\sigma / d\log L = 1/15$

Note: L is the disk luminosity.

g-modes

$\epsilon_{nj} \approx \frac{n+1/2}{j+\delta}\left(\frac{h}{r}\right)$, $\quad \frac{h}{r} \sim 0.1 \frac{L}{L_{Edd}}$



$F(a)$

For $m \gg 1$, $\frac{\sigma_m}{\sigma_0} \cong m\Omega(r_i)$

Fig. 4—(a) The dependence of the maximum radial ($m = 0$) eigenfrequency on the black hole angular momentum parameter $a = cJ/GM^2$. $[F(-1) = 0.60]$

(b) The ratio of the maximum eigenfrequency of the higher m modes to that of the radial mode.

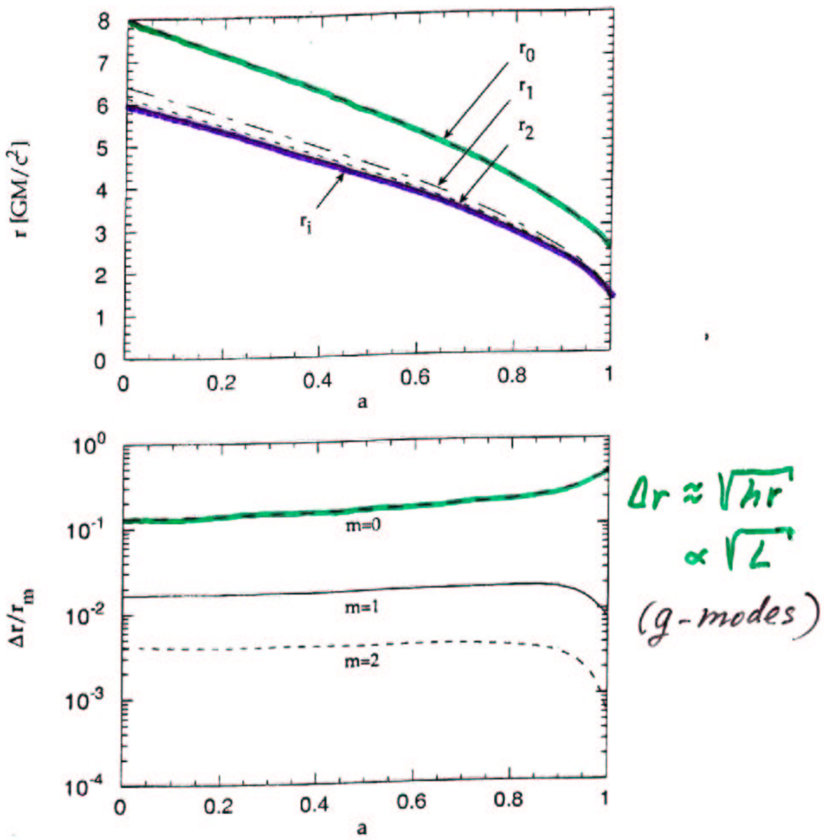


Fig. 5—(a) The black hole angular momentum dependence of the radius r_m to which r_- and r_+ converge as $|\sigma| \to \sigma_m$. Also shown is the radius r_i of the inner edge of the disk.

(b) The dependence of the fractional effective width of the lowest eigenfunction, $\Delta r/r_m = [r_+(\sigma) - r_-(\sigma)]/r_m$, on the angular momentum of the black hole. The same values of m are chosen as in (a). The accretion disk model is specified by $\Gamma = 4/3$, a locally isentropic equation of state, and speed of sound corresponding to a luminosity $L = 0.1 L_{Edd}$ from a radiation-dominated disk.