AGA 315 Aula 15

Buracos negros 2 (observaçõeS)

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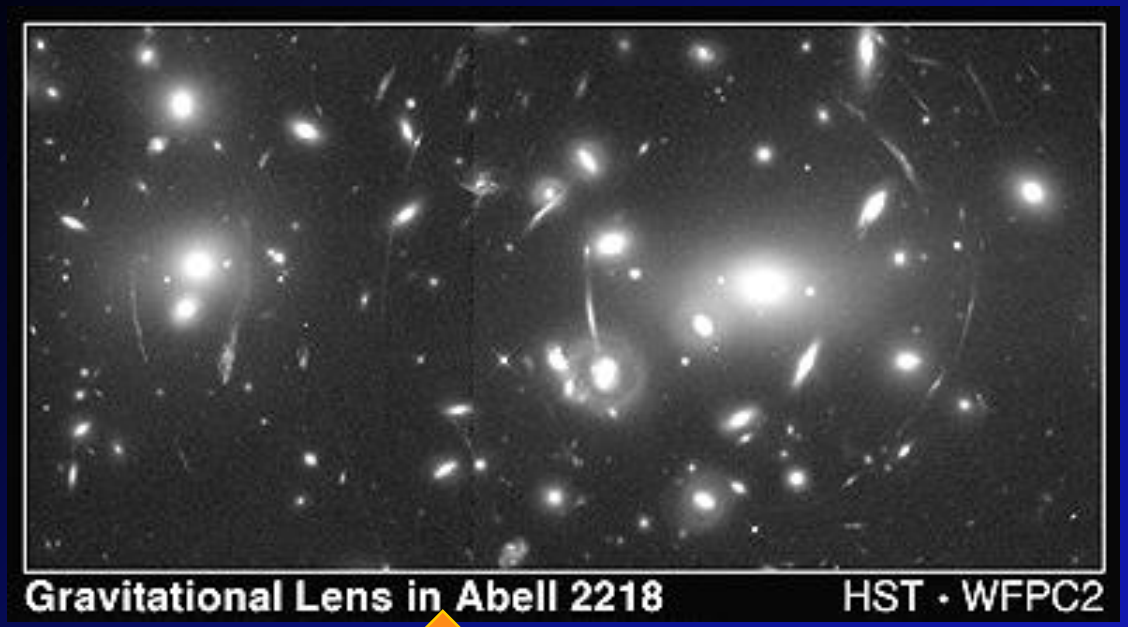
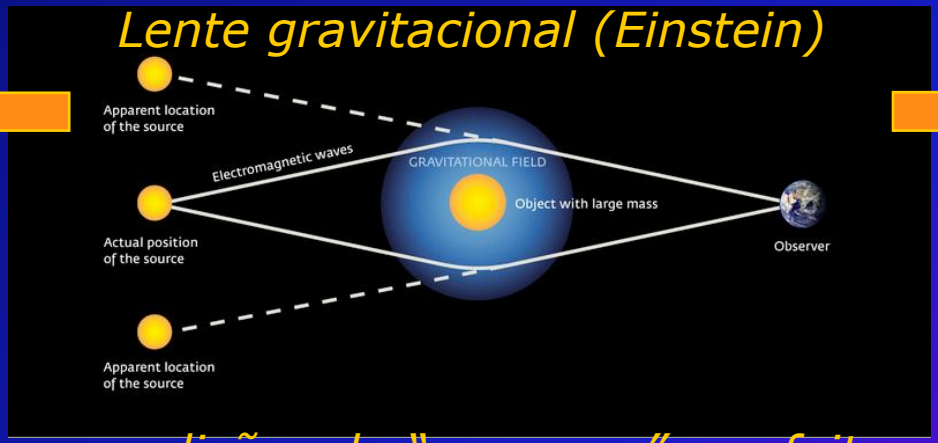
O quê veriamos ao olhar (de longe) para um buraco negro ?
A distorção das imagens de background

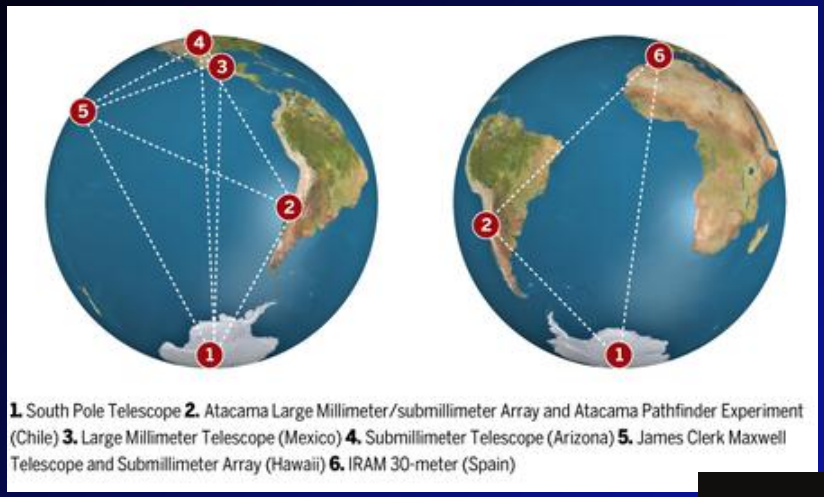


Lente gravitacional (Einstein)



*Para estarmos em condições de "enxergar" os efeitos de **lensing** e a eventual entrada de matéria no BH, devemos resolver ~ μarcsec*

➡ Horizon Event Telescope



1. South Pole Telescope **2.** Atacama Large Millimeter/submillimeter Array and Atacama Pathfinder Experiment (Chile) **3.** Large Millimeter Telescope (Mexico) **4.** Submillimeter Telescope (Arizona) **5.** James Clerk Maxwell Telescope and Submillimeter Array (Hawaii) **6.** IRAM 30-meter (Spain)

Resolução angular de μarcsec é possível somente se a baseline é muito grande: utiliza-se a Terra

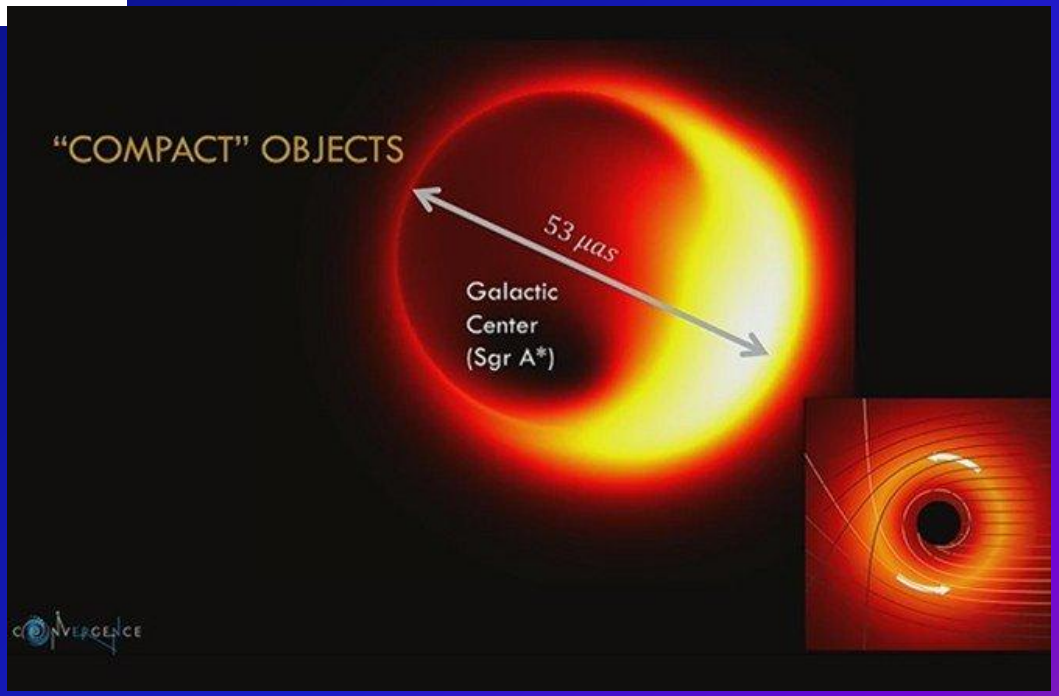


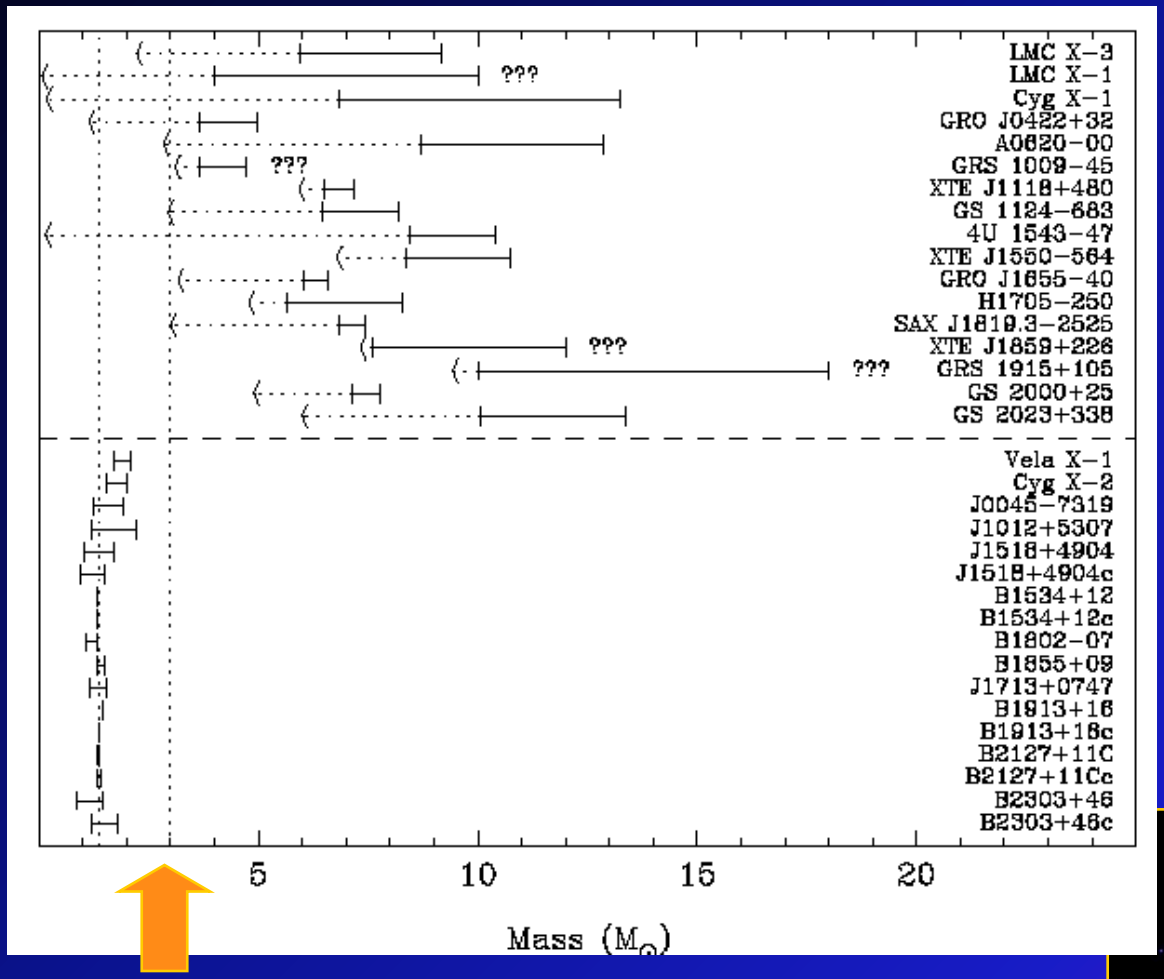
Imagem simulada, observação real em andamento (outubro 2017)

As 3 espécies de BH

- *Primordiáis (pesos ultra-leves, já discutidos)*
- *Estelares (pesos médios)*
- *Supermassivos (pesos pesados)*

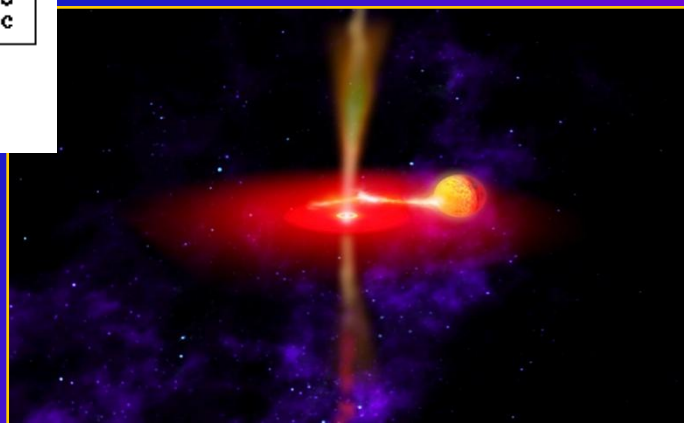
Formação e evolução diferentes, mas a estrutura é idêntica

Buracos negros remanescentes da evolução estelar : os pesos médios



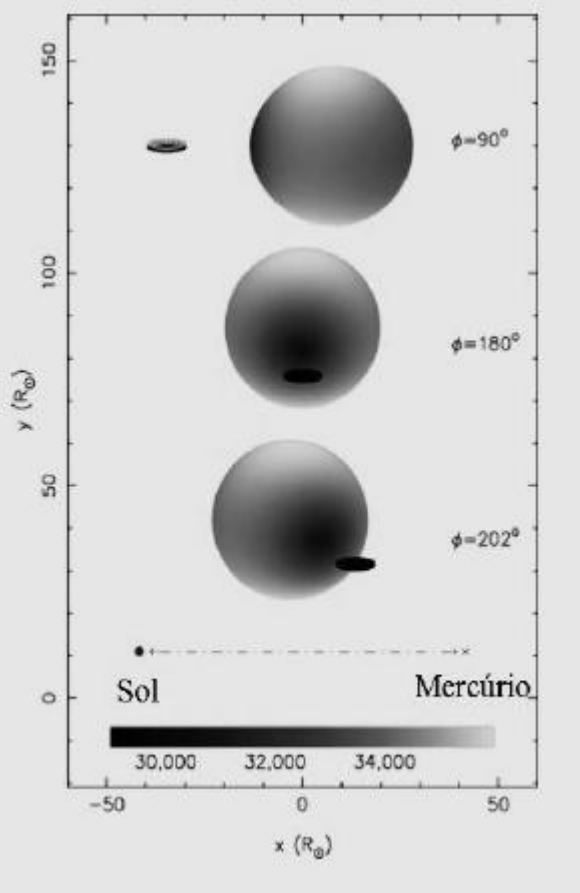
Binárias medidas
(3ra Lei de Kepler)

Apartir daqui não há como eles serem estrelas de nêutrons

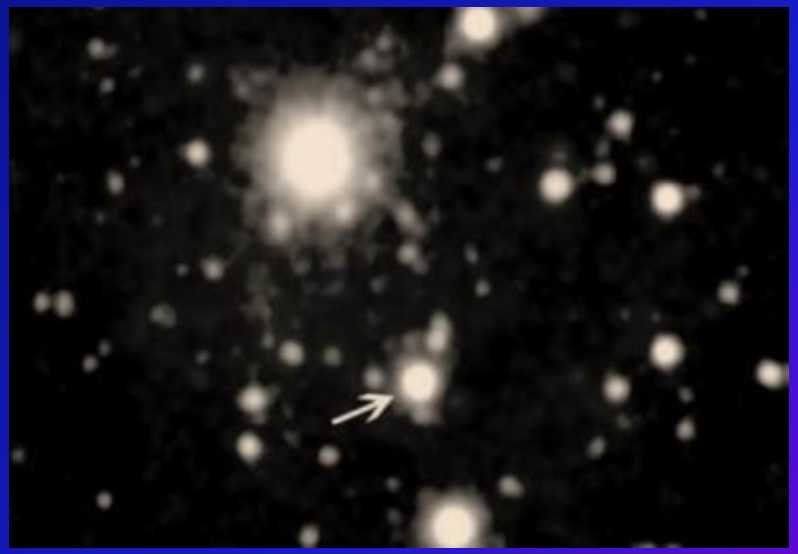


O caso do M33 X7: eclipses da companheira pelo disco de acresção

$$f(M_1, M_2, i) = \frac{(M_2 sen^2\alpha)^3}{(M_1+M_2)^2} = \frac{P v_{\parallel}^3}{2\pi G}$$

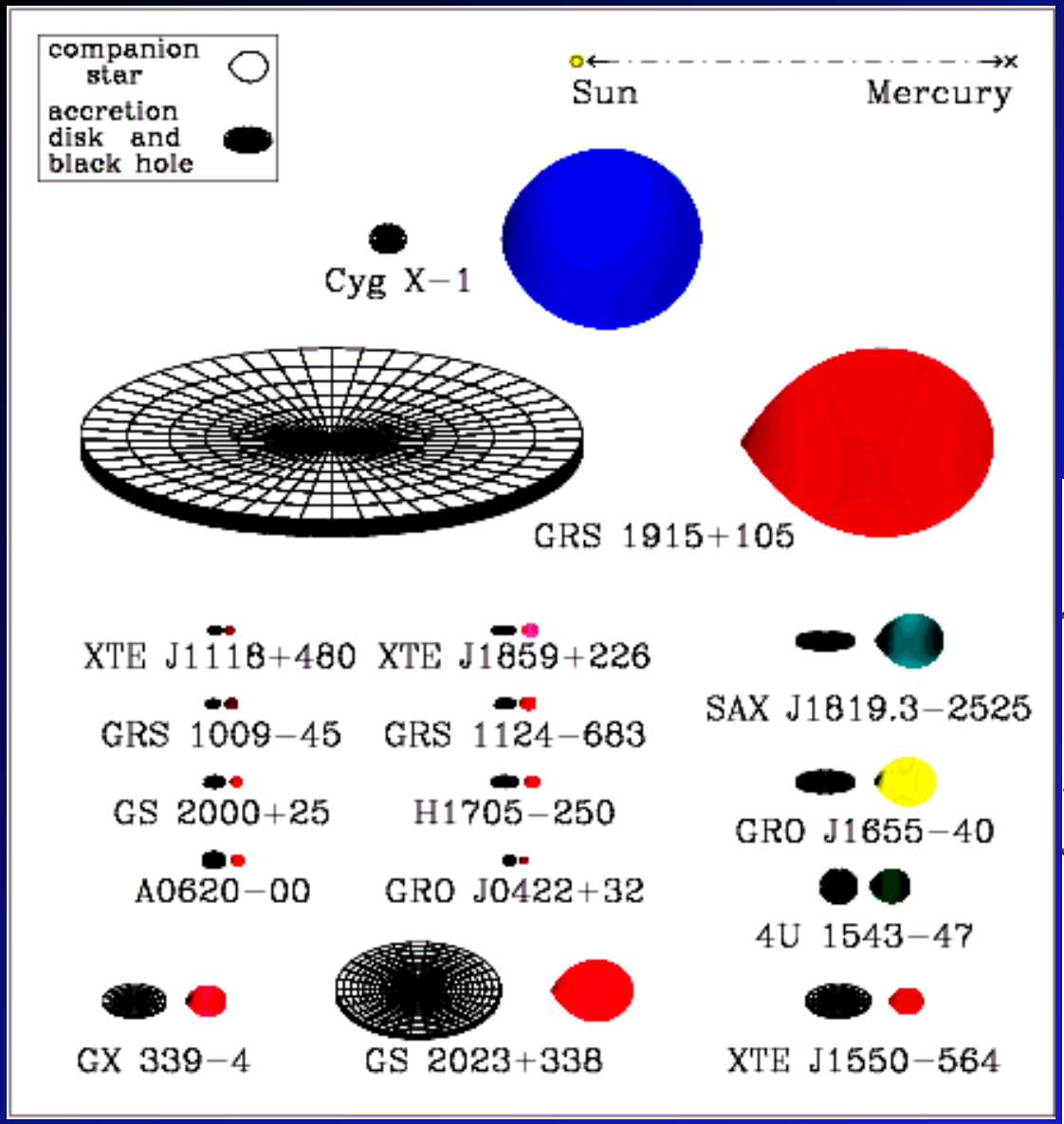


sen²α fortemente limitado pela observação dos eclipses



A companheira no óptico: M~ 70 $M_\odot$

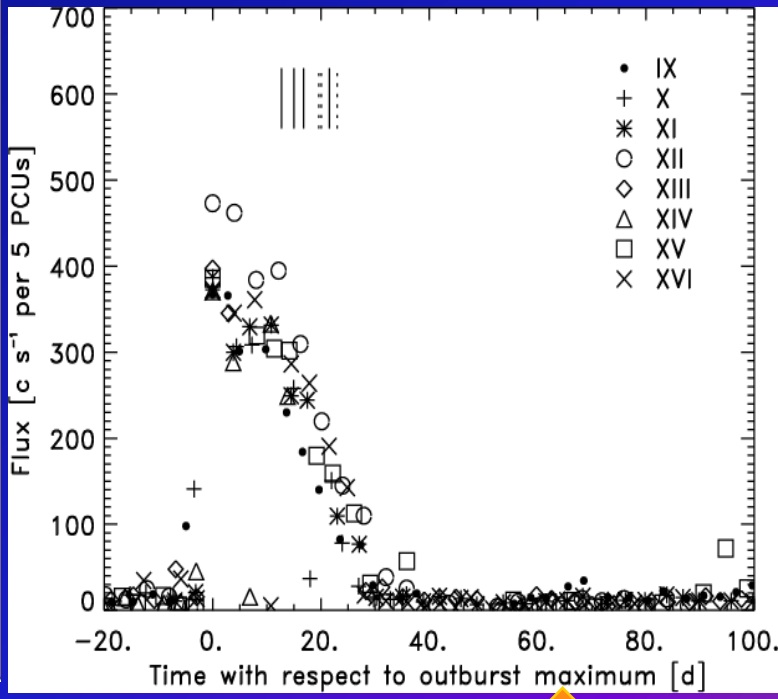
M_{BH}~ 16 $M_\odot$



Binárias de raios X que contém candidatos a BH

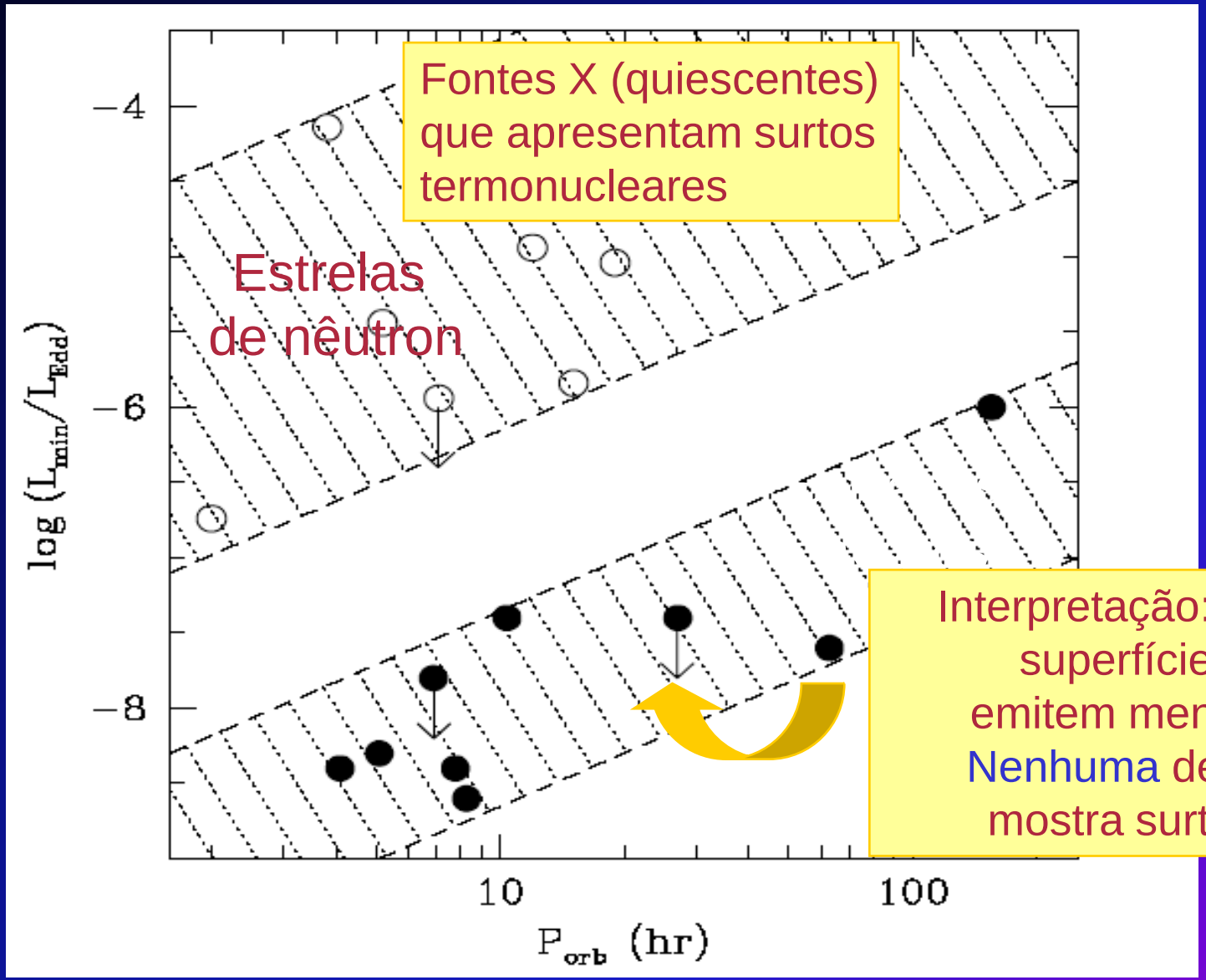
função de massas

$$f(M_1, M_2, i) = \frac{(M_2 sen^2\alpha)^3}{(M_1+M_2)^2} = \frac{P v_\parallel^3}{2\pi G}$$

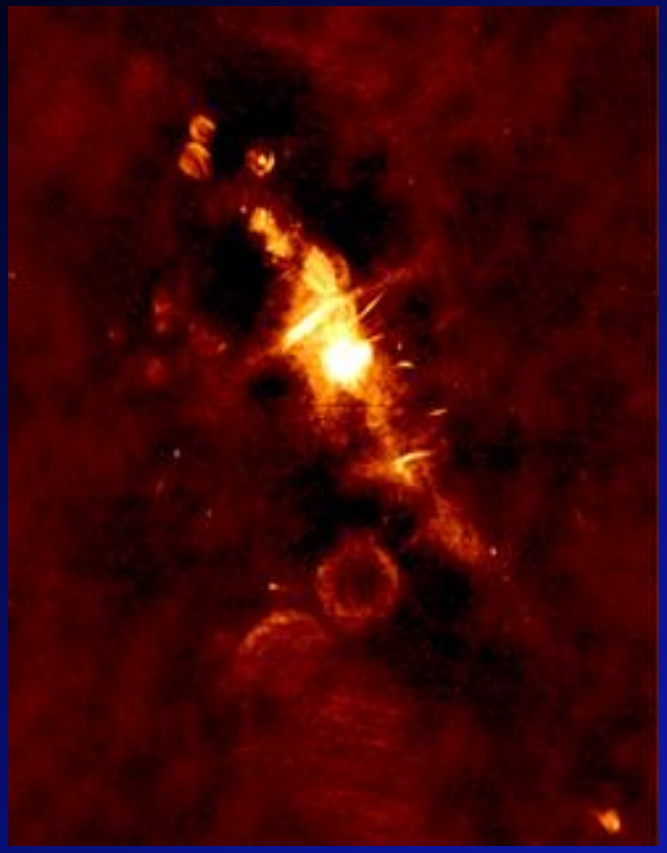


Algumas delas apresentam *surtos* visíveis em raios X

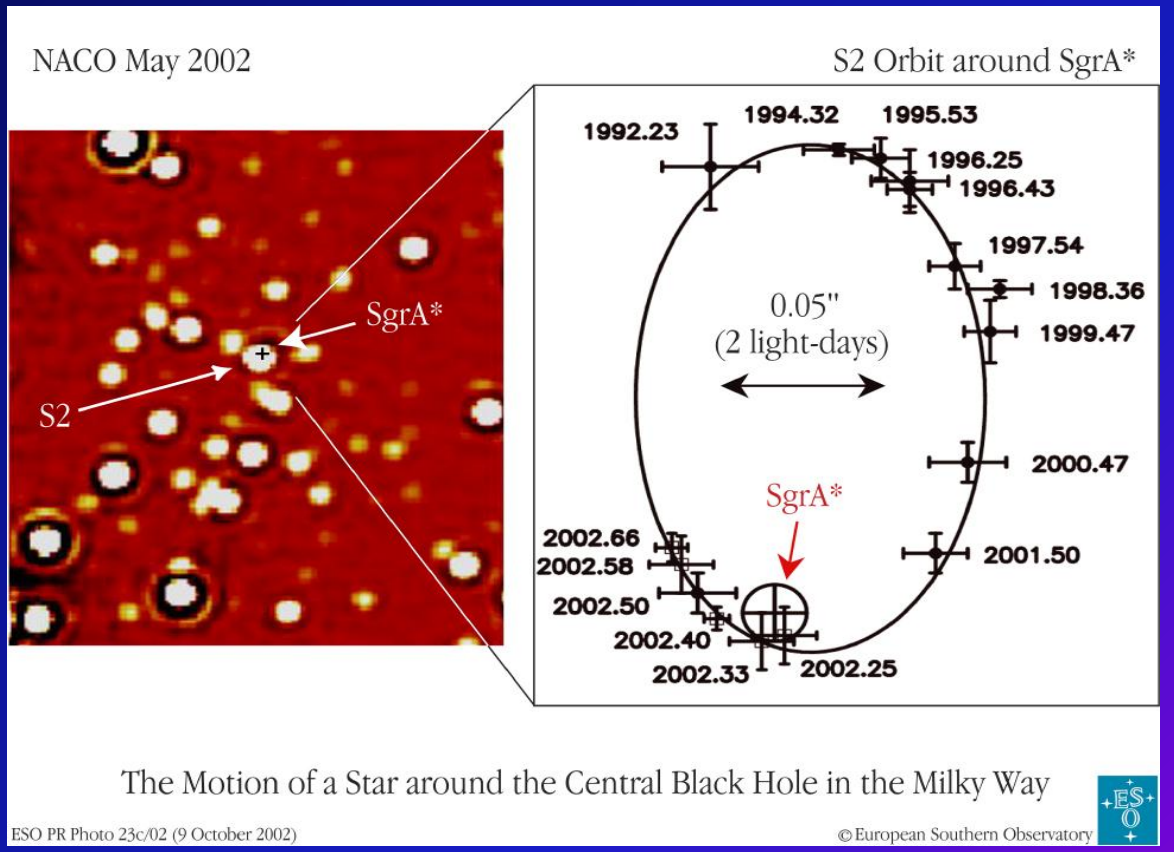
Uma prova da existência de BH em binárias?



Os pesos pesados : Sagittarius A no centro da Via Láctea

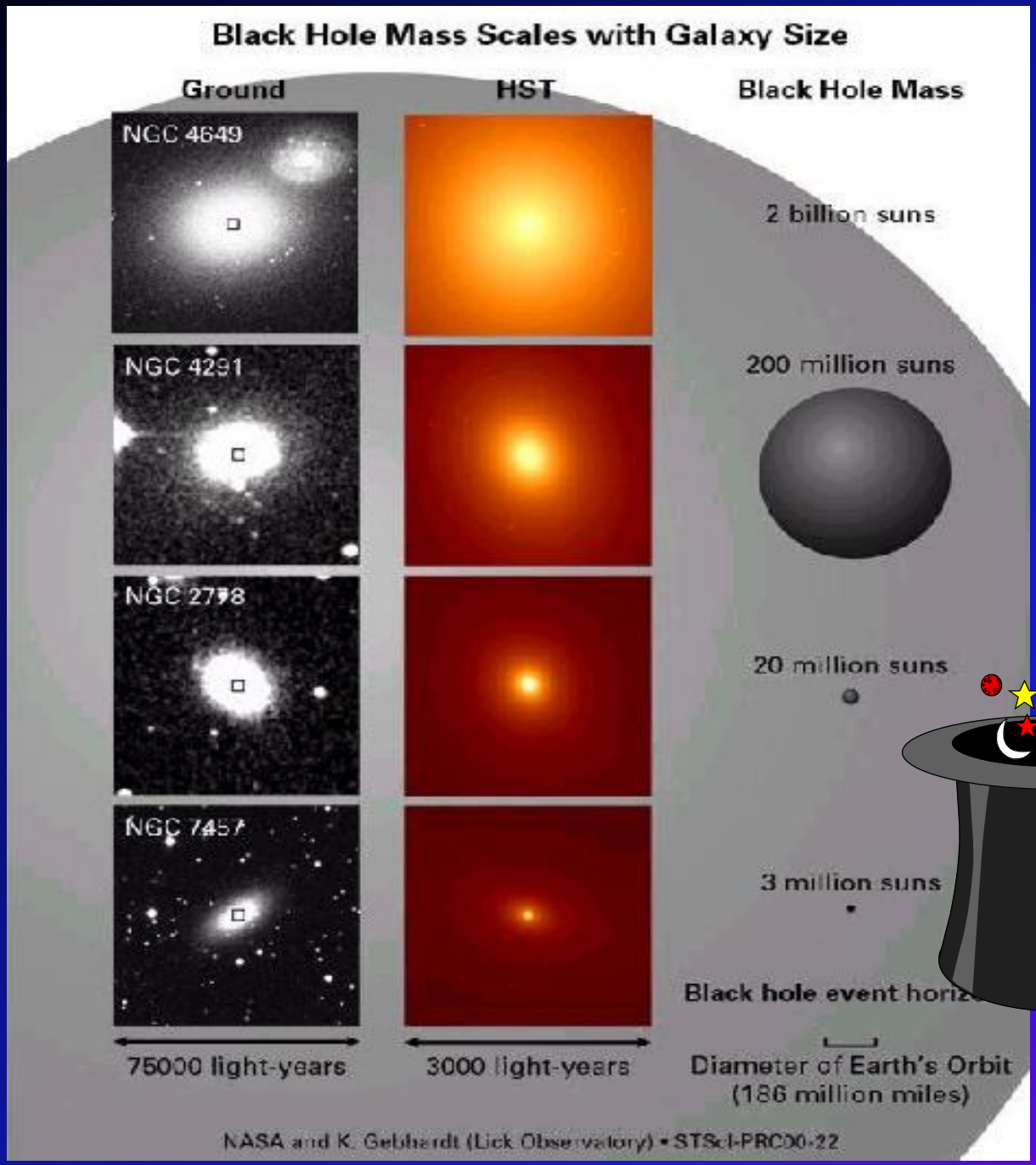


Saggitarius A em rádio (!)

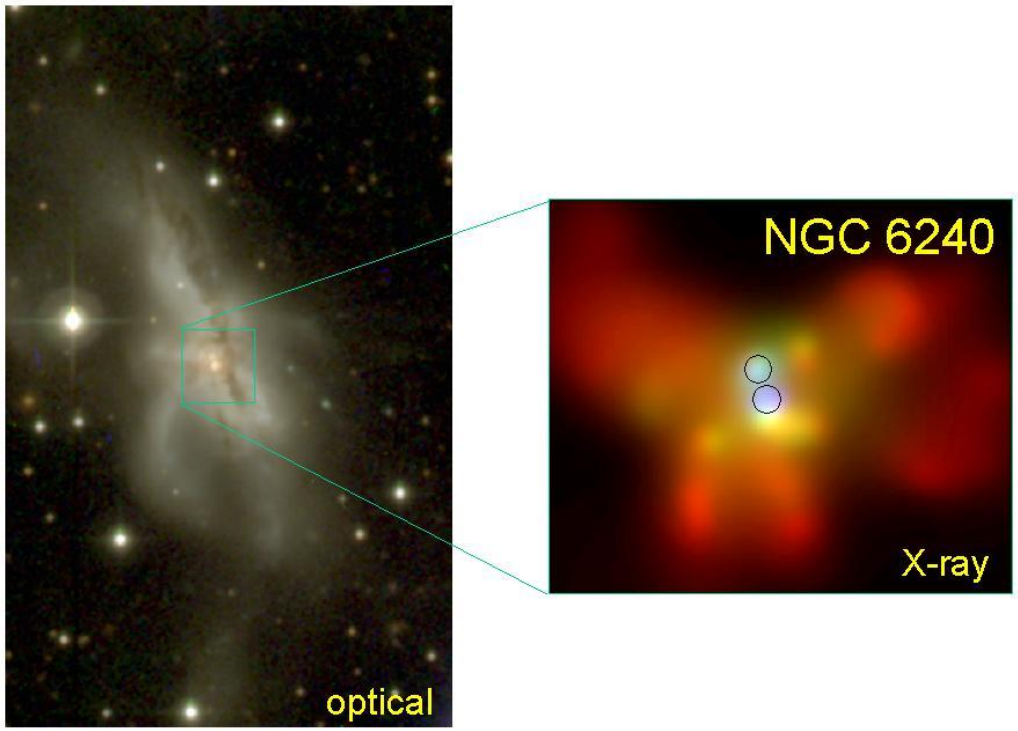


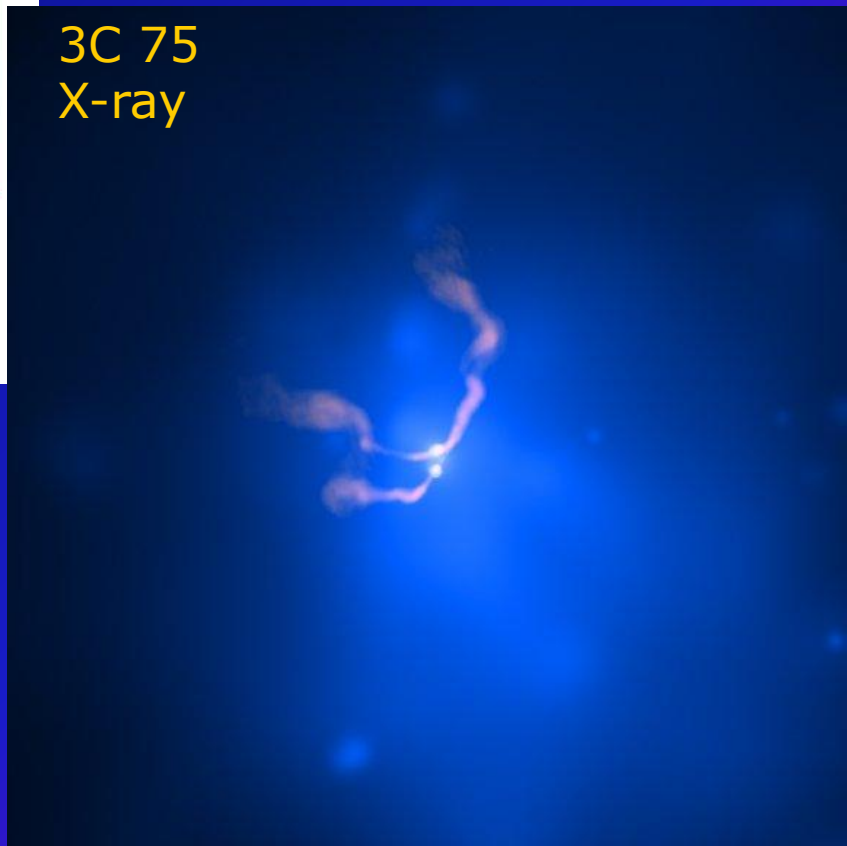
"+" indica a posição de Sag A, usando a Terceira Lei de Kepler

$$P^2 \propto a^3 \Rightarrow M = 2.6 \times 10^7 M_\odot$$


Black Hole Mass Scales with Galaxy Size
Ground
HST
Black Hole Mass
NGC 4649
2 billion suns
NGC 4291
200 million suns
NGC 2778
20 million suns
NGC 7457
3 million suns
Black hole event horiz
75000 light-years
3000 light-years
Diameter of Earth's Orbit
(186 million miles)
NASA and K. Gebhardt (Lick Observatory) • STScI-PRC00-22

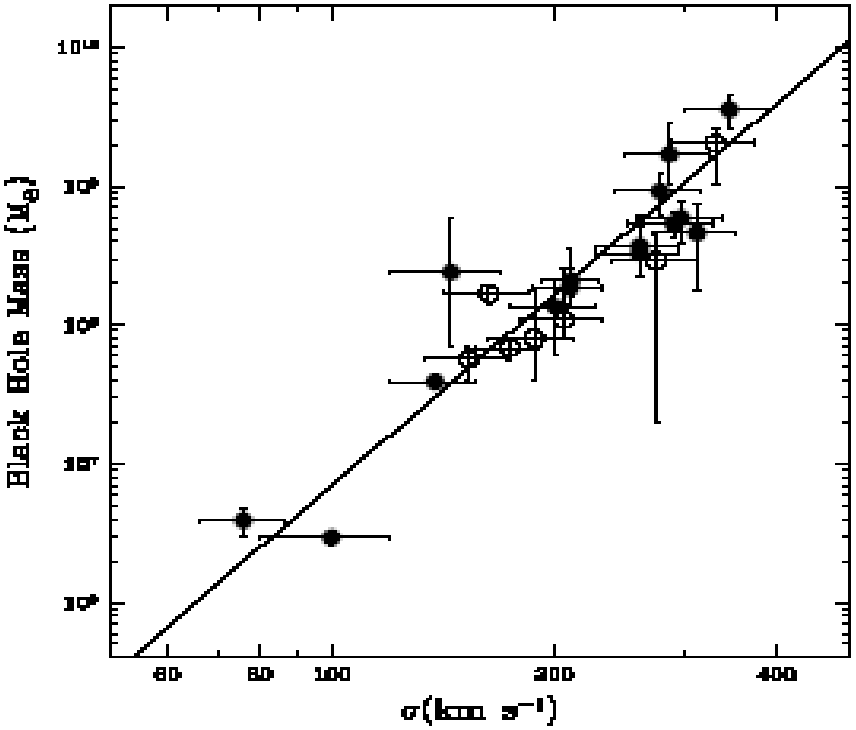
As vezes há dois buracos por falta de um...

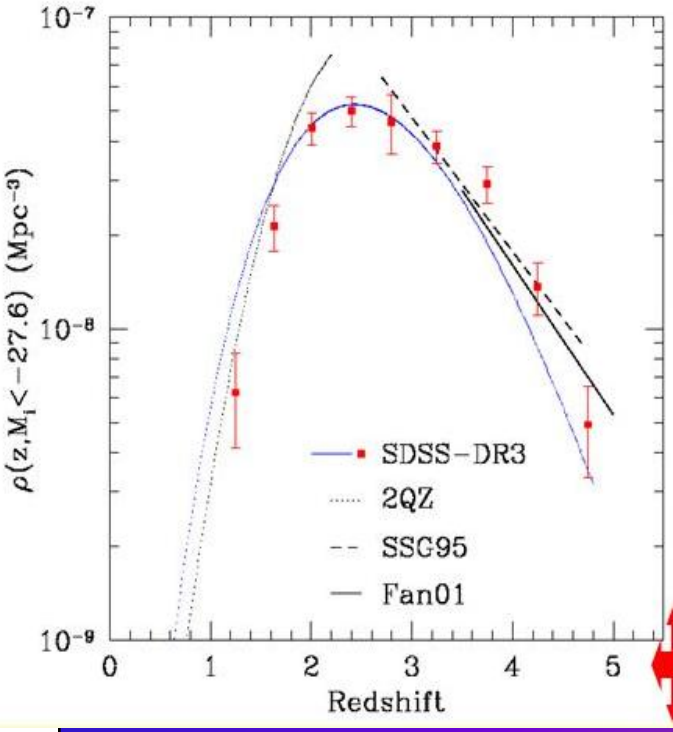




O problema do ovo e a galinha :
a galáxia precede o SMBH ou vice-versa ?

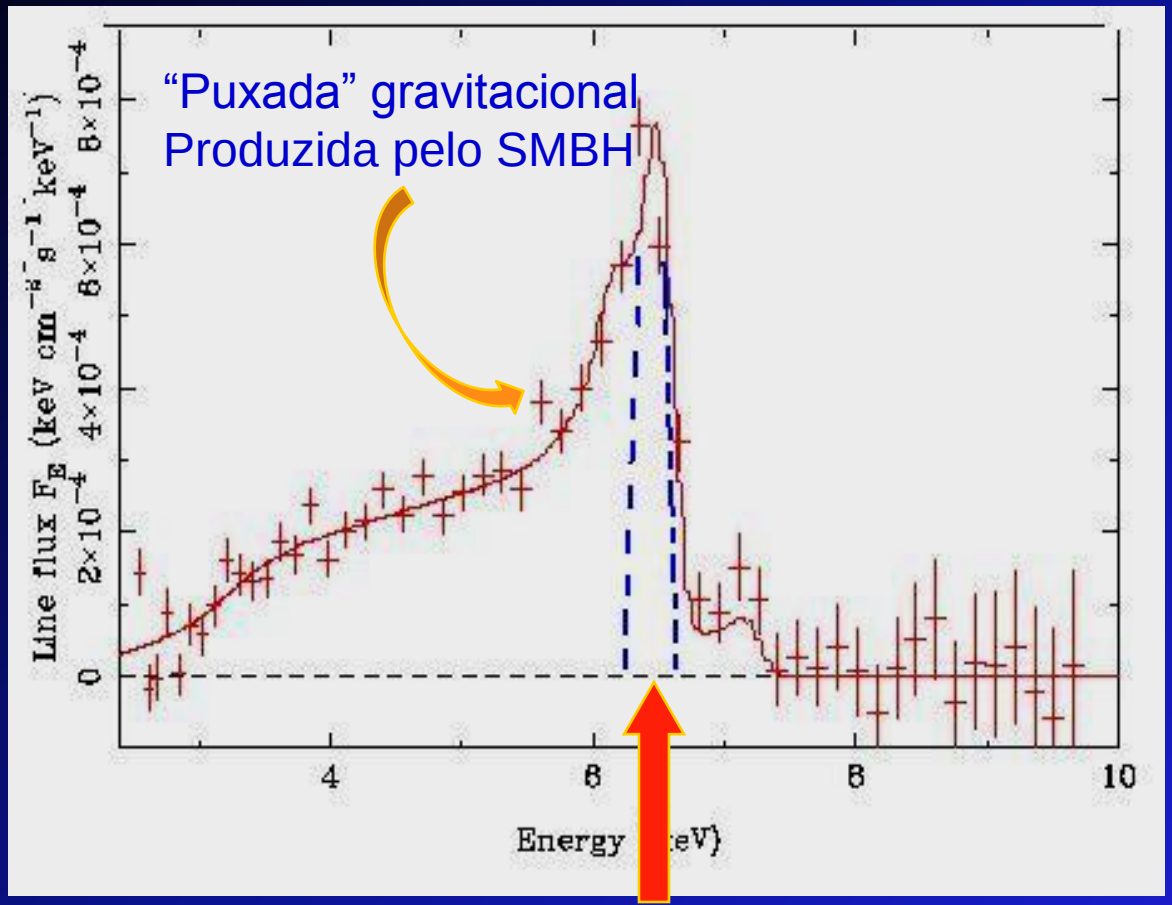
A atividade galáctica (quasares) começa em z > 6 :
houve tempo para formar os SMBH ?



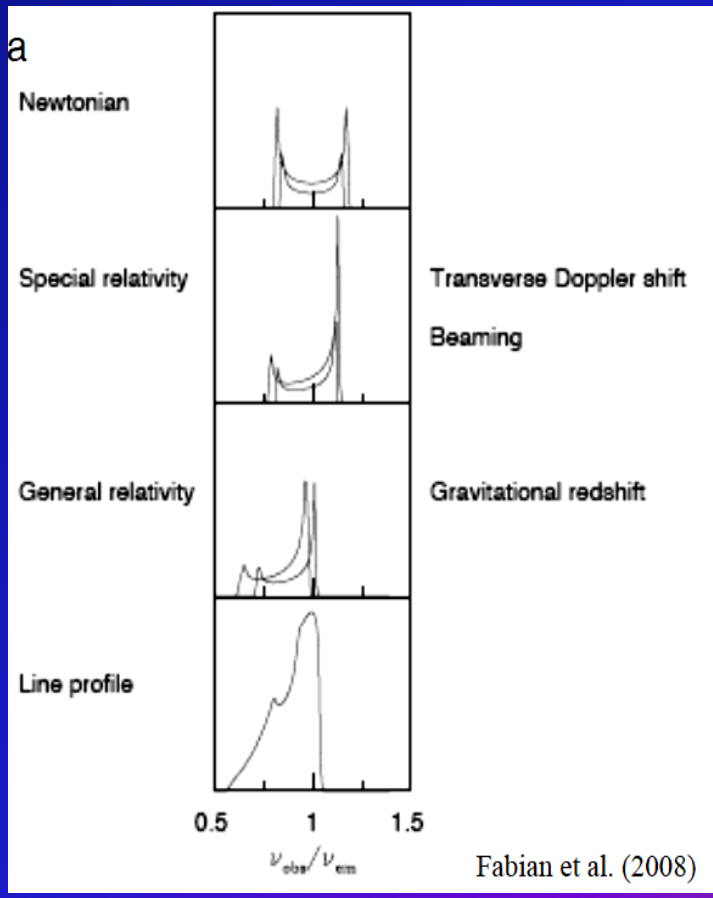


O buraco negro e a galáxia estão intimamente relacionados !

Mais evidências dos SMBH : o caso do gás em MCG-6-30-15

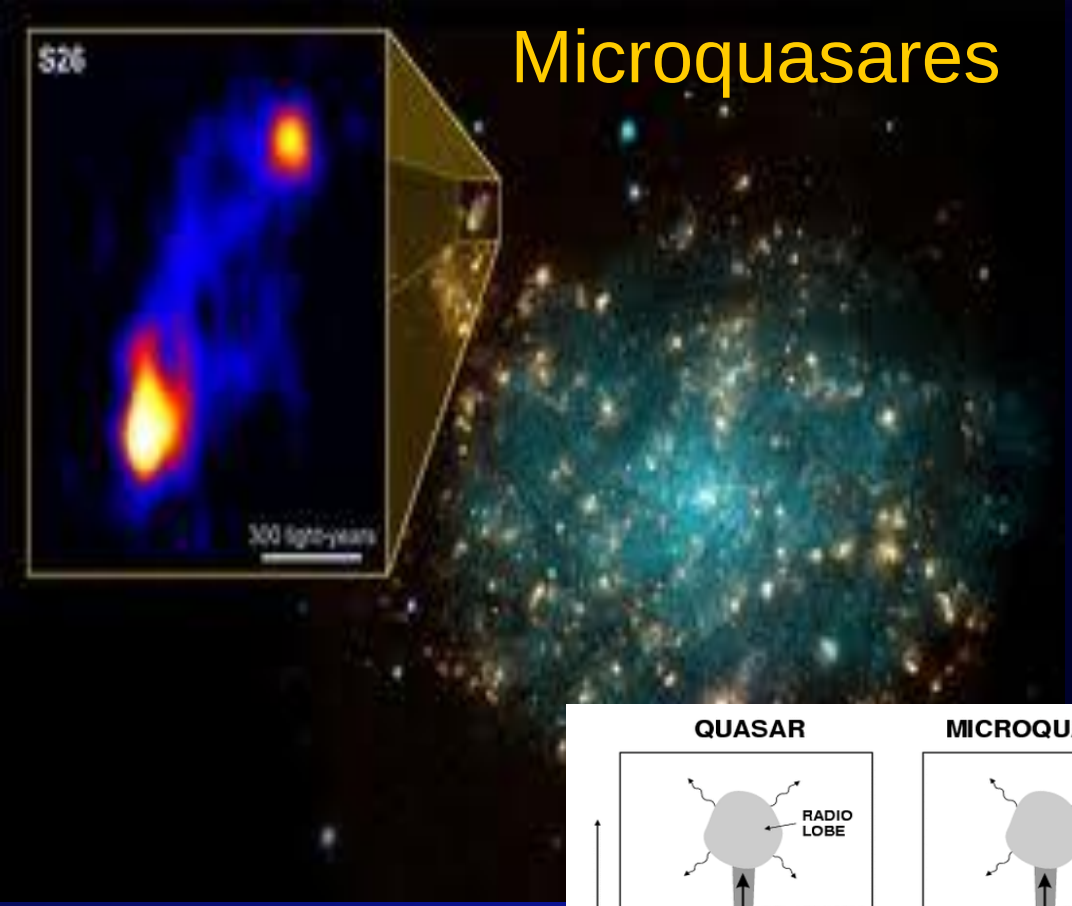


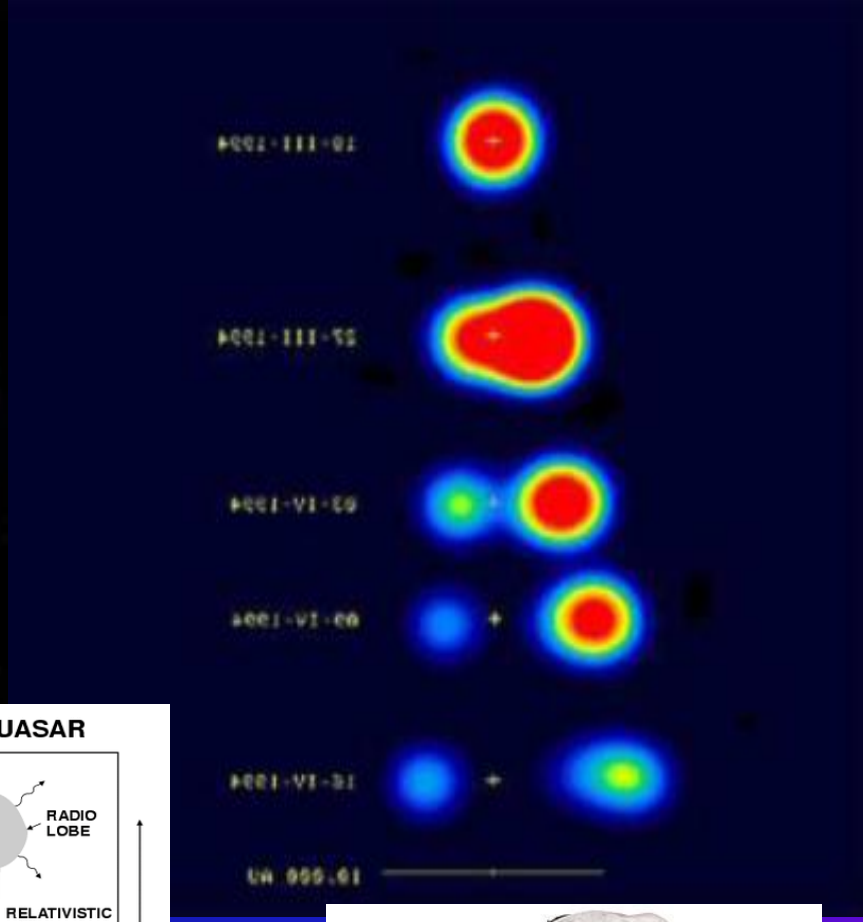
Linha K_α do Fe @ 6.4 keV
(largura normal em azul)



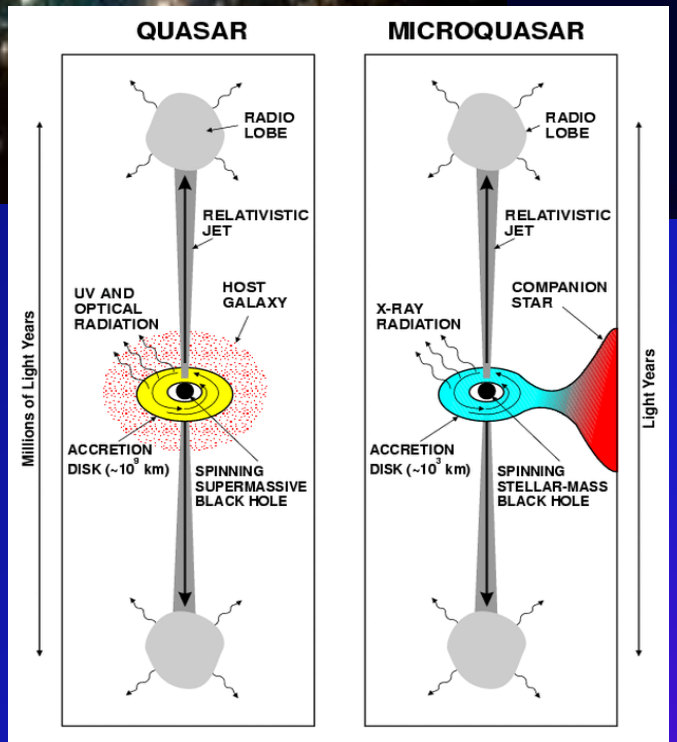
Teoria vs. Linha real

Microquasares

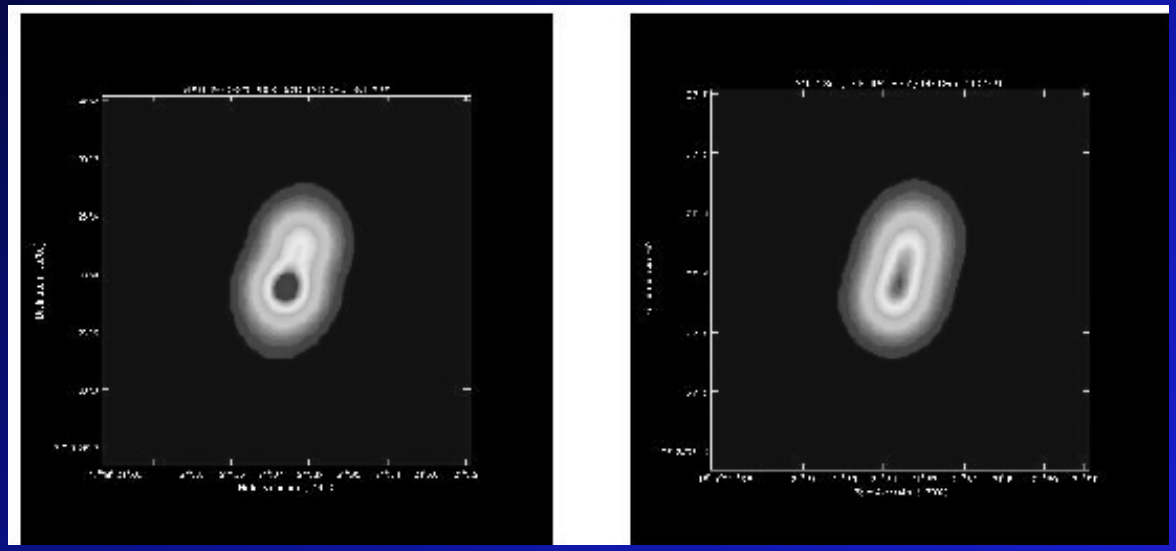




Rodríguez *Mirabel*



V4641 o micro-quasar (buraco negro) mais próximo da Terra (ao que saibamos...)



As duas imagens foram obtidas com intervalo de ~30 min (!), a variabilidade é muito rápida e corresponde a uma distância de ~500 pc

Surtos de raios gama : os eventos mais energéticos do Universo depois do Big Bang

Nasce um buracos negro estelar
por dia no Universo visível ?

(e destrói vida ao longo do seu caminho?)

Mais noticias na aula dos surtos gama…

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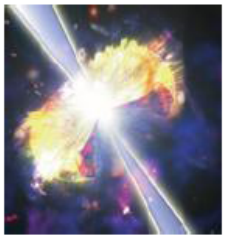

Death from across the galaxy

Feb. 27, 2007
Special to World Science

A type of colossal cosmic explosion could beam lethal radiation across a galaxy, frying any life forms in its path, a new analysis has found.

The blasts are thought to occur rarely in our Milky Way galaxy, but more often in those where stars are born and die more frequently. These include areas where astronomers hope to find Earth-like planets ripe for life.

In a 1995 study, Steve Thorsett of Princeton University in Princeton, N.J. calculated that such events, called gamma-ray bursts, might wreak havoc on an Earth-like planet if they occurred near it. But scientists don't fully understand the extent of the possible damage. Especially unclear is how far a burst would have to occur to affect life, according to the authors of the new study.

Gamma-ray bursts are flashes of high-energy radiation found to occur randomly in space. At least some are thought to be associated with extremely massive stars that, having burnt out, collapse to form black holes.

In the new research, Douglas Galante and Jorge Ernesto Horvath of the University of São Paolo, Brazil, argued that gamma-ray bursts could shine their lethal effects across a whole galaxy, and damage life over greater distances still. The study is to appear in a forthcoming issue of the *International Journal of Astrobiology*.

Conclusões

Hoje há forte evidência da presença de buracos negros estelares e supermassivos, e intenso estudo dos PBH. Os buracos negros são tão reais para os astrônomos quanto as estrelas ordinárias ...

Inúmeros problemas na astrofísica dos buracos negros precisam ser resolvidos, mas podem ser estudados baseados em observações factíveis já