

Эволюция звезд и черные дыры



Звезды

Масса: $0.001 M_{\odot} < M < 100 (300) M_{\odot}$

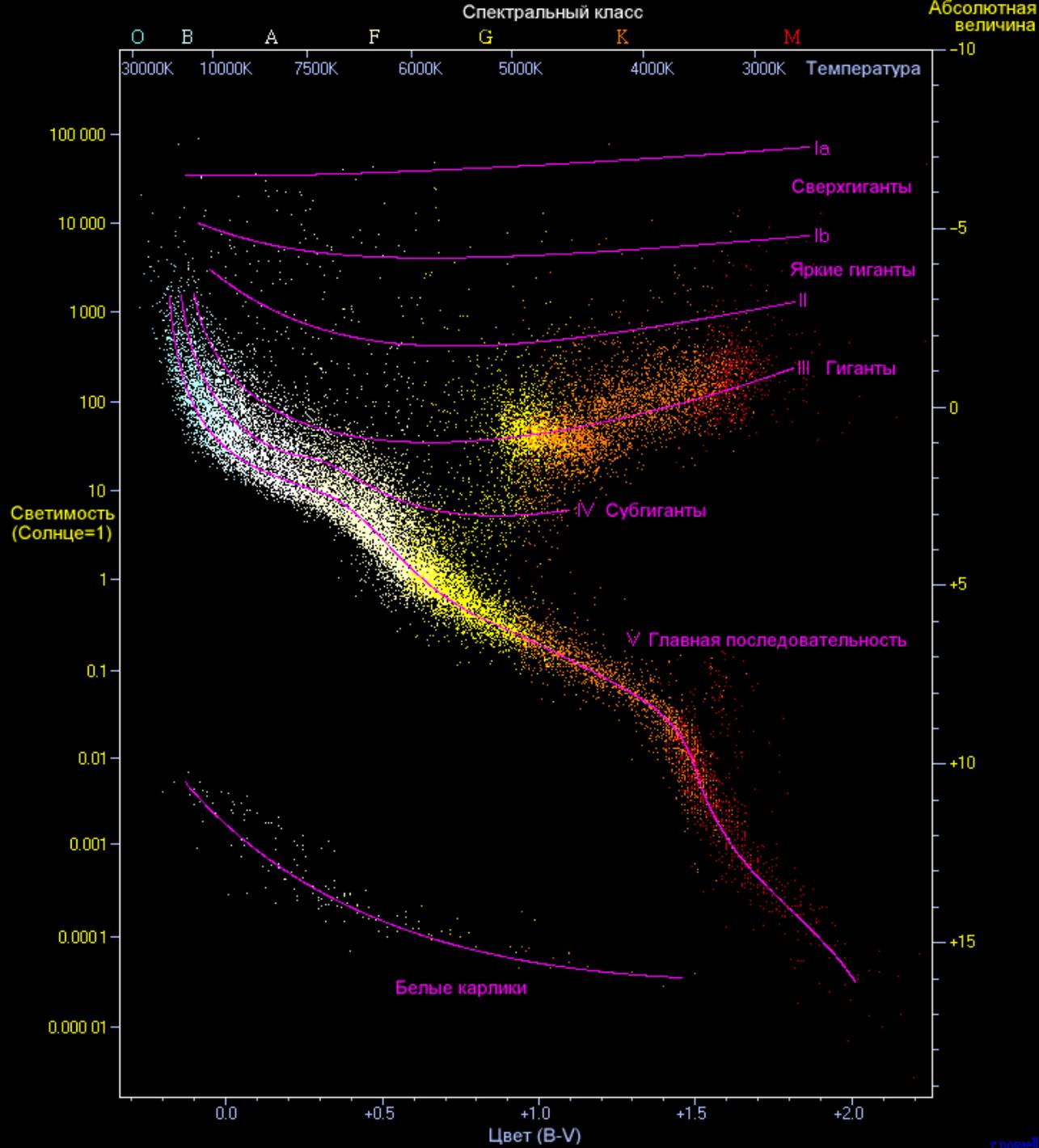
Светимость: $10^{-4} L_{\odot} < L < 10^6 L_{\odot}$

Размер: $0.1 R_{\odot} < R < 30 R_{\odot}$

Время жизни: $T_{\text{яд}}$ от 10^6 лет до H^{-1} и более

Химический состав: от первичного (H, He) до солнечного

Частота рождения в галактиках от 0,01/год до 10/год



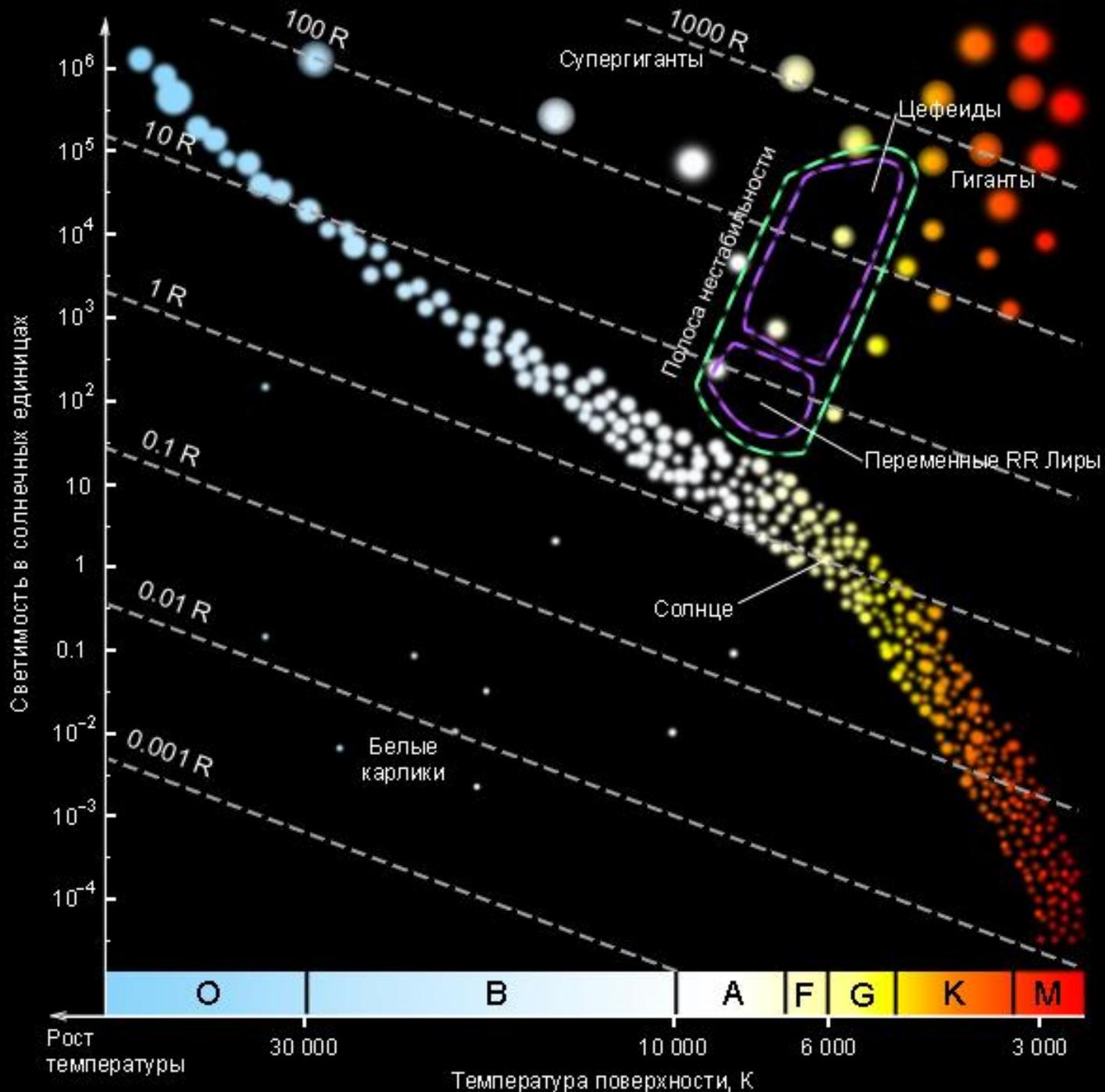
Эволюция звезд

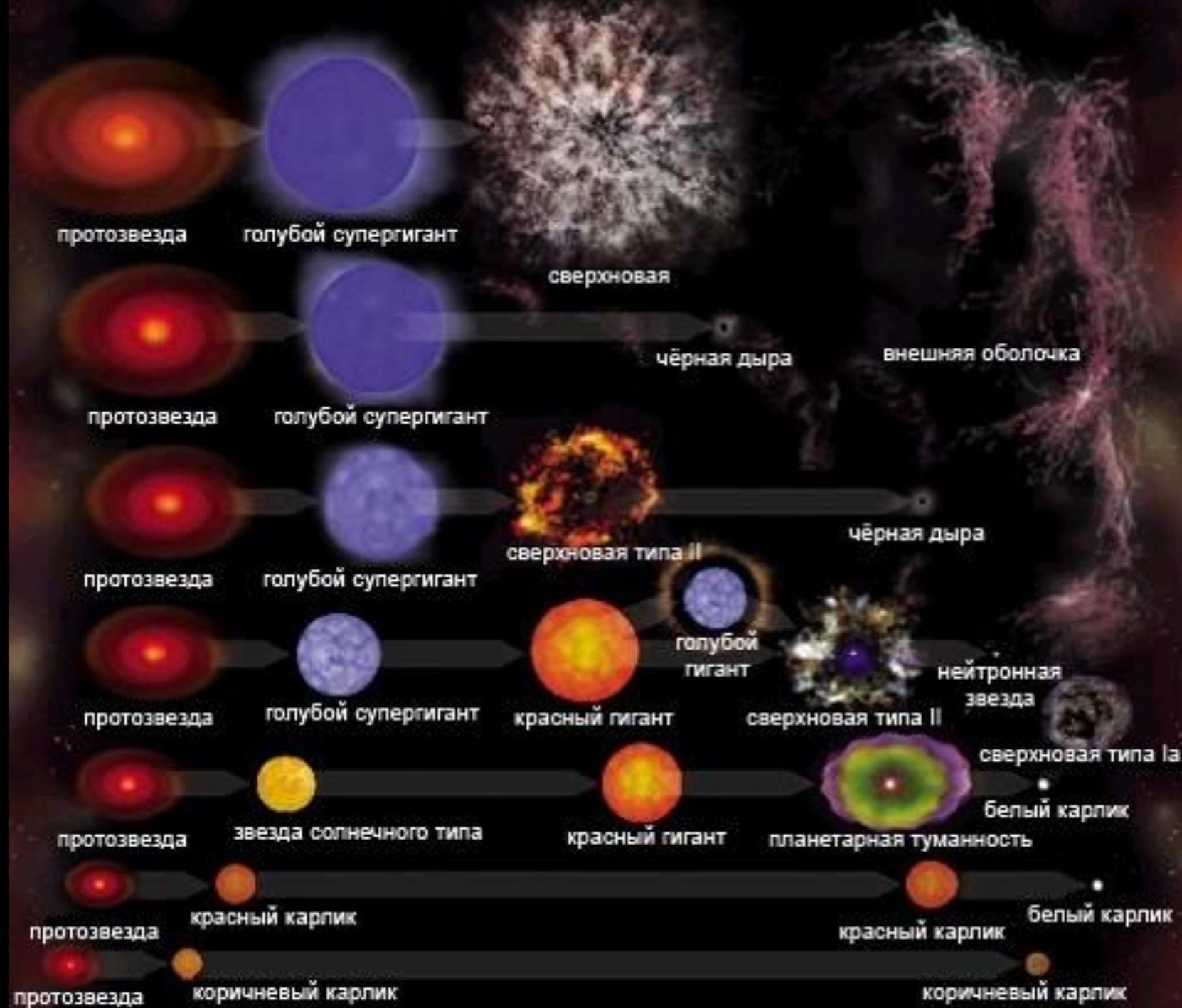
Ядерное время: $T_{\text{яд}} = 10^{10} \text{ m l}^{-1}$ лет

Тепловое время: $T_{\text{кн}} = GM^2/RL = 3 \cdot 10^7 \text{ m}^2 \text{ r}^{-1} \text{ l}^{-1}$ лет

Динамическое время: $T_{\text{д}} = R/c_s$, несколько часов

$T_{\text{кн}}$	сжатие	гравитационная энергия
$T_{\text{яд}}$	ГП	ядерная энергия, $\text{H} \rightarrow \text{He}$
$T_{\text{кн}}$	гигантизм	$\text{He} \rightarrow \text{C, N, O}$
$T_{\text{д}}$	SN	сброс оболочки
время ↓	BH, NS, WD	

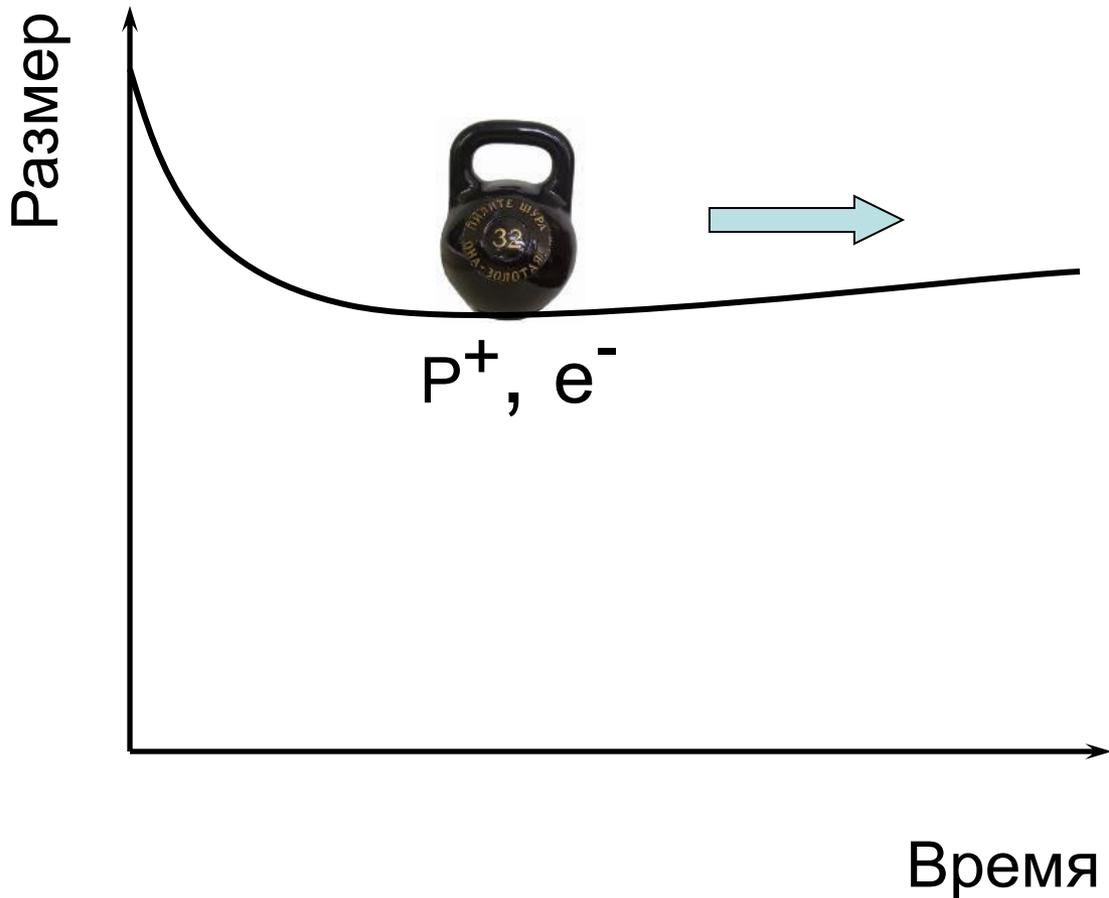




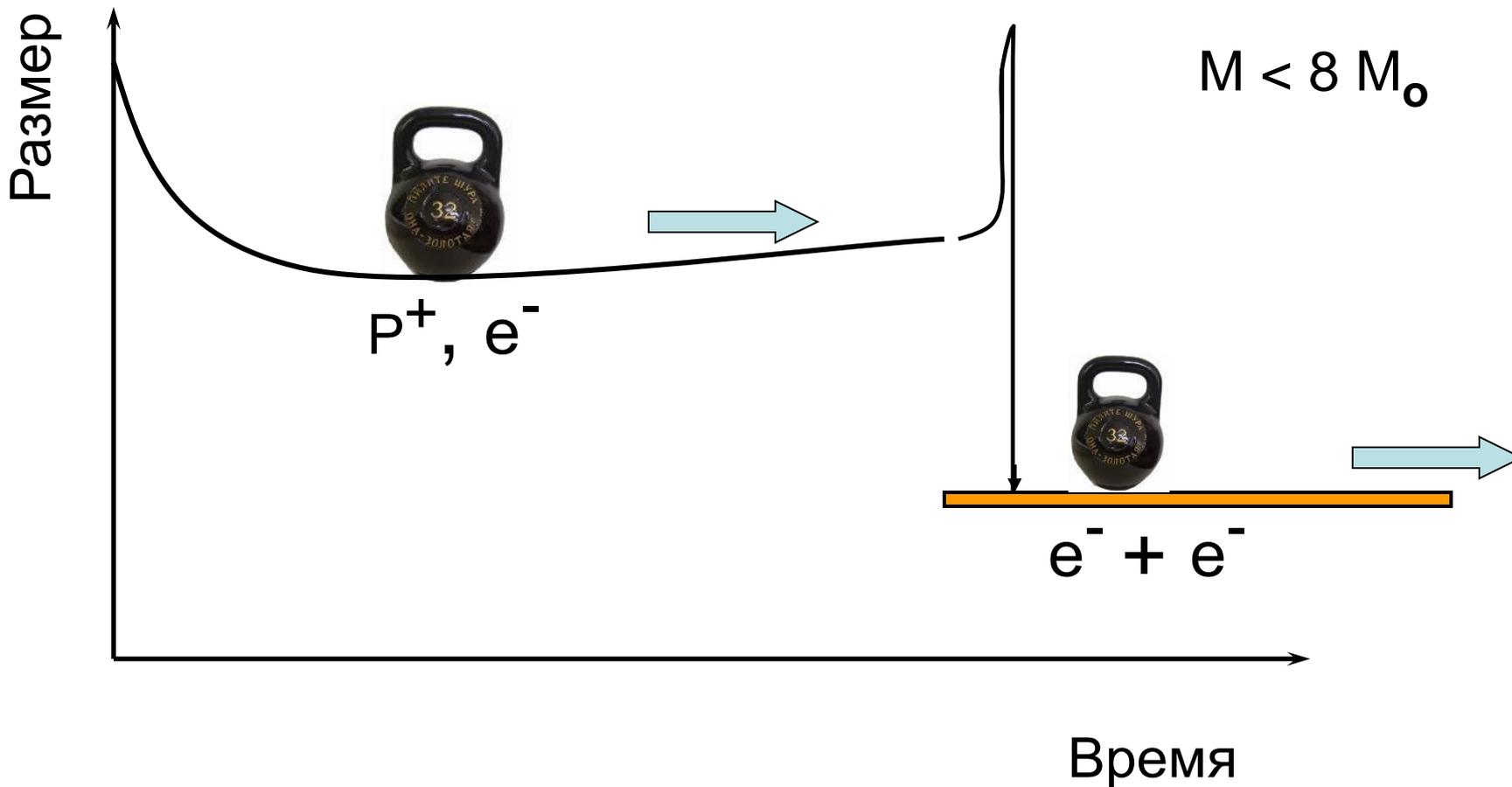
Маломассивные звезды

$$M < 0.6 M_{\odot}$$

$$T > 13 \text{ млрд. лет}$$

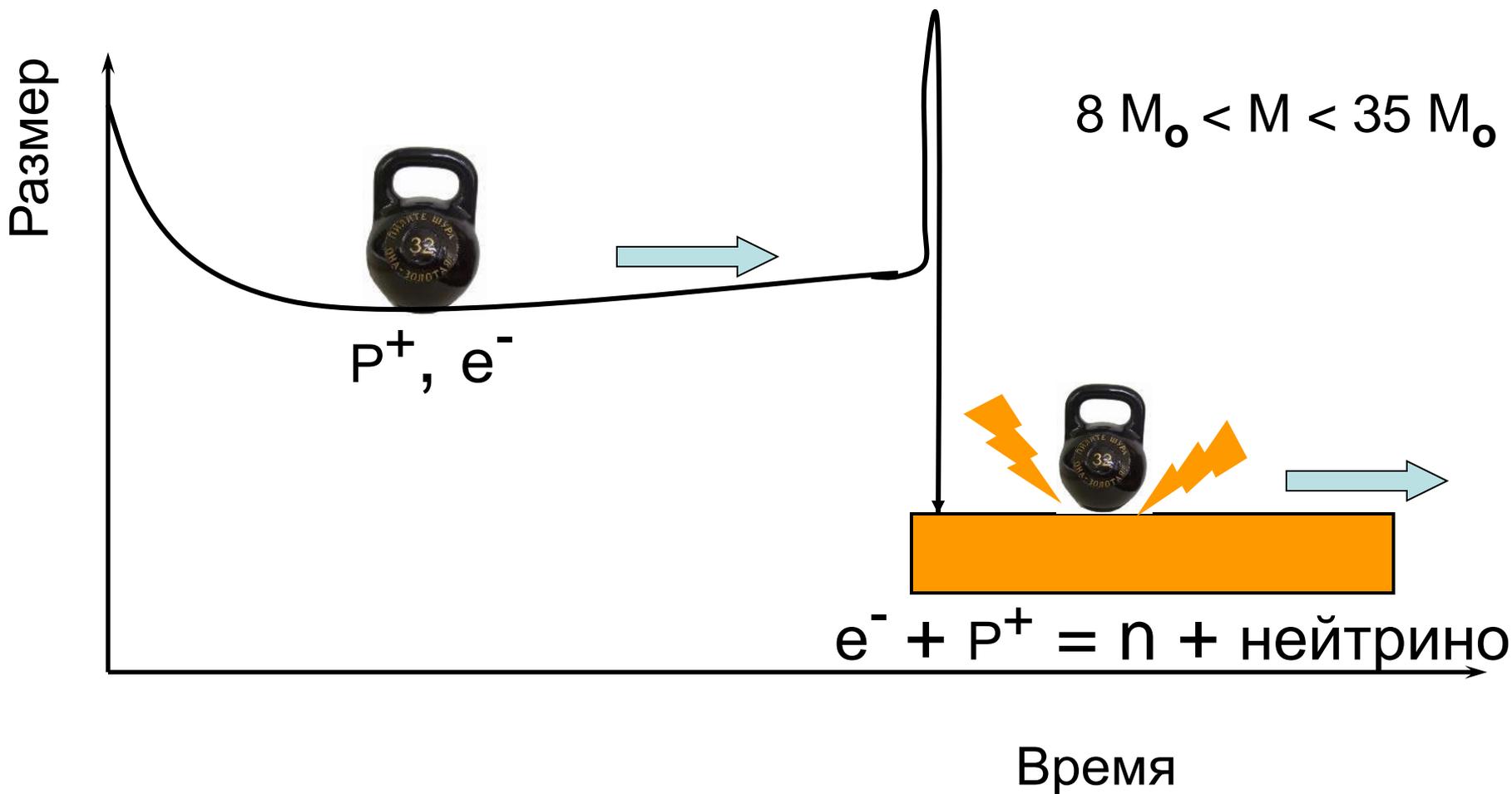


Образование белого карлика



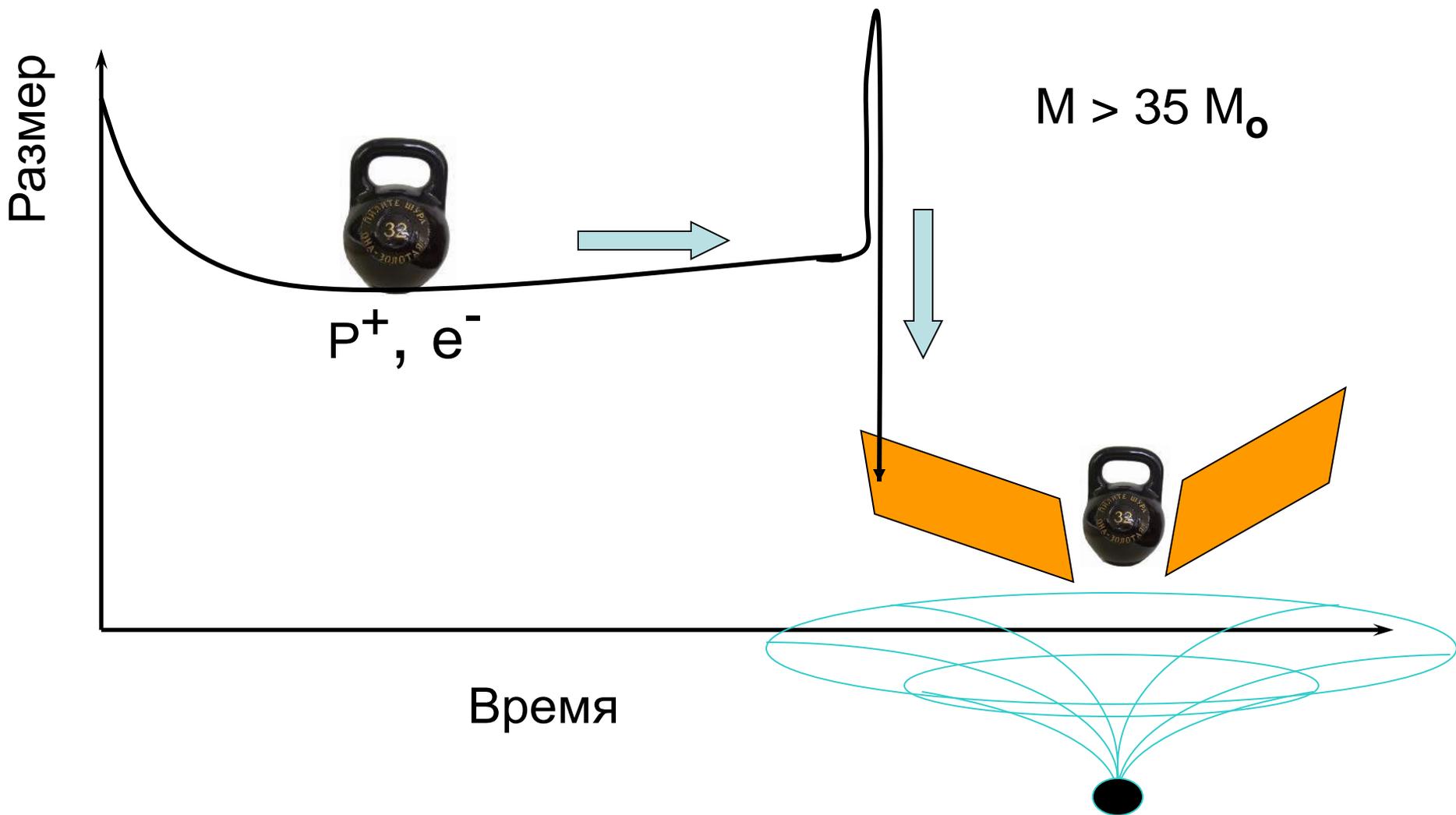
Предел Чандрасекхара $1.4 M_{\odot}$

Образование нейтронной звезды

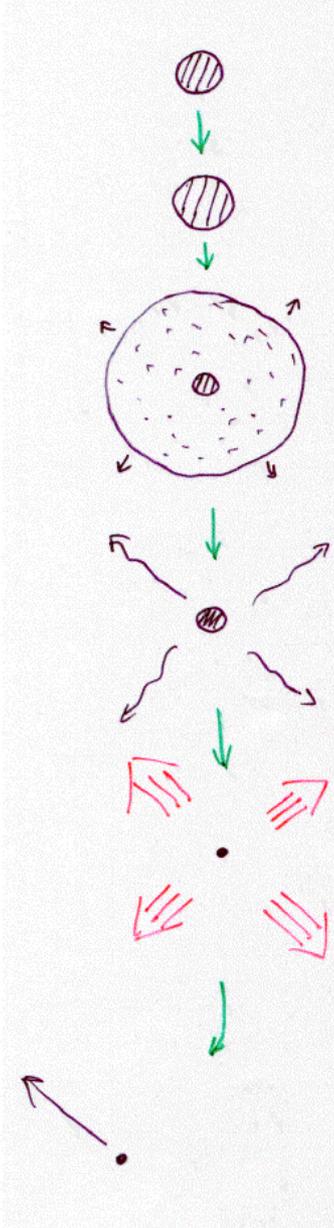


Предел Опенгеймера-Волкова $1.5-2 M_{\odot}$

Образование черной дыры



Массивные звезды. Одиночная звезда:



ГП, $T_{\text{яд}}$

Гигант, $T_{\text{кн}}$

WR

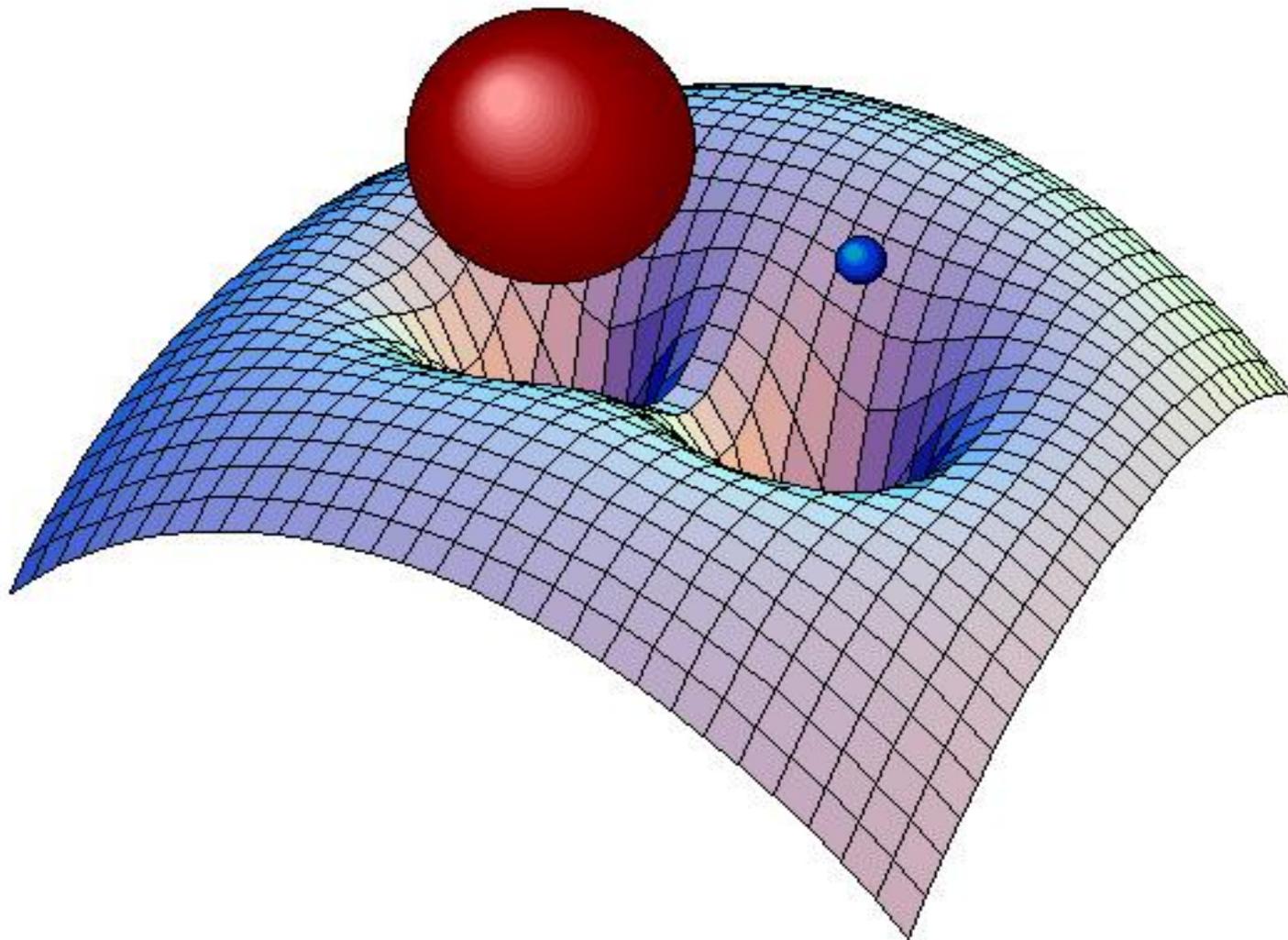
SN

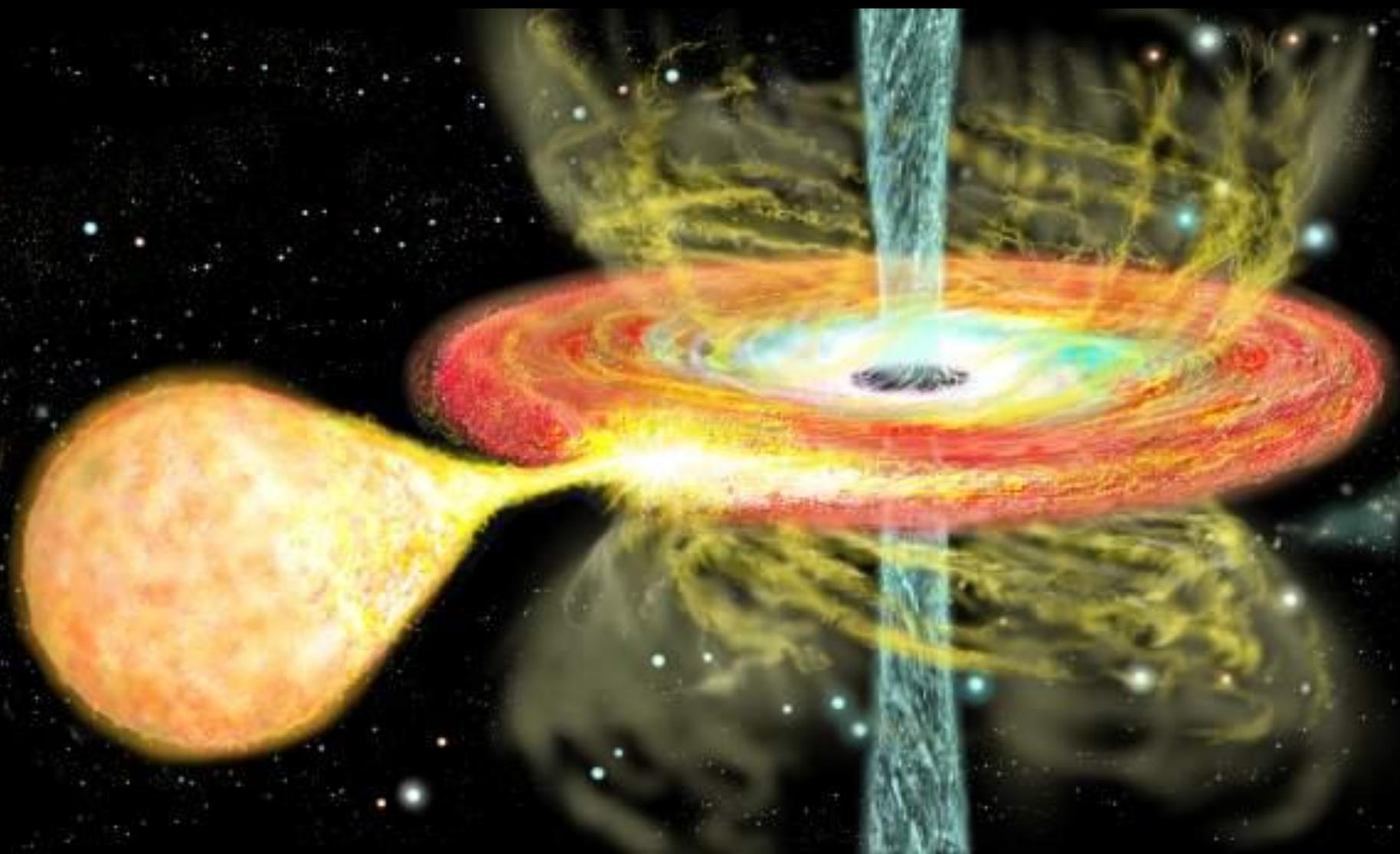
Черная дыра или
Нейтронная звезда

Нейтронная звезда Краб
рентгеновский телескоп Chandra



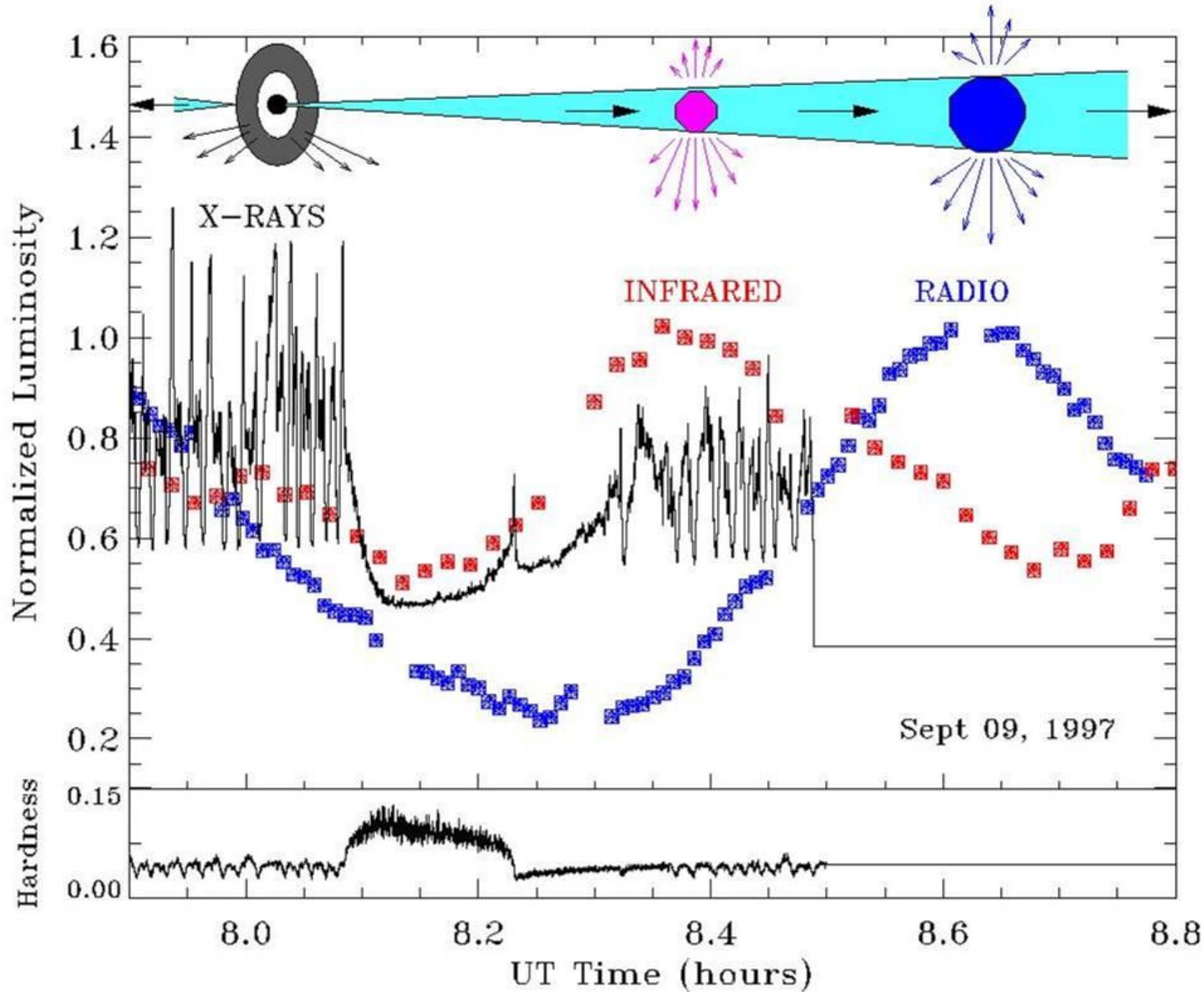
Полости Роша

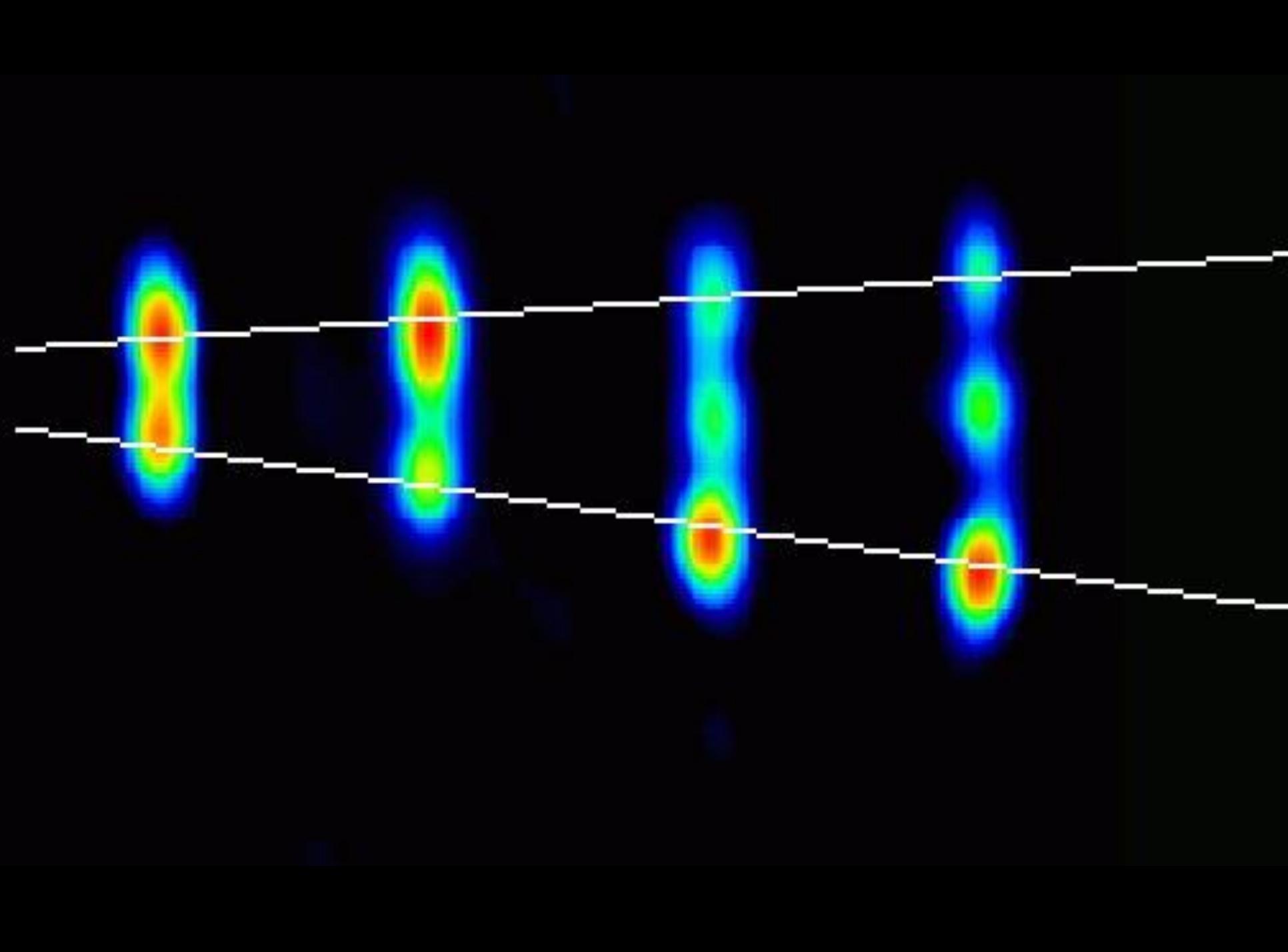


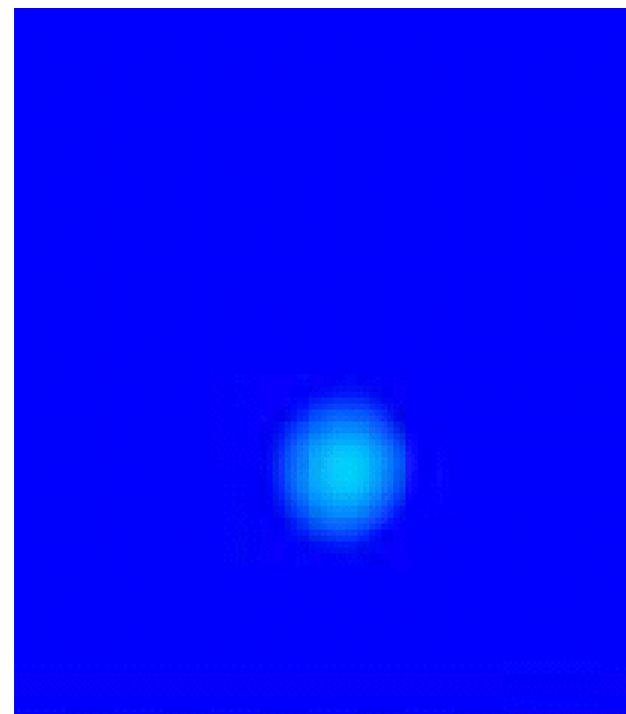
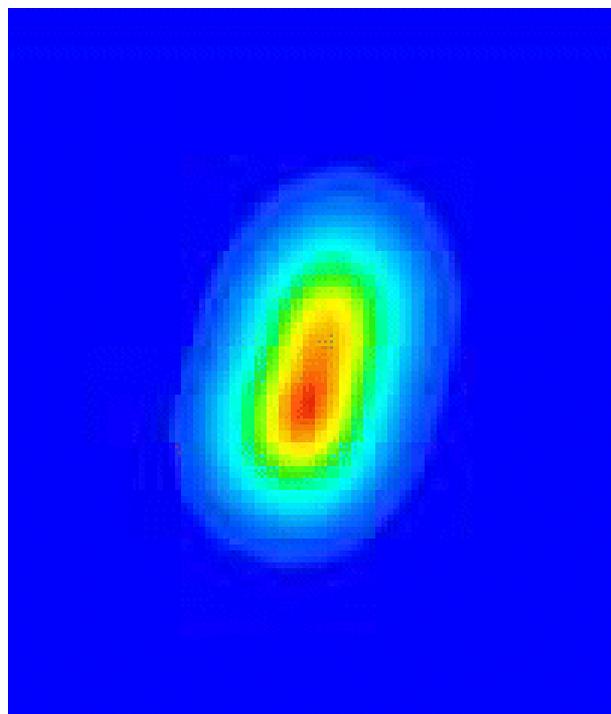
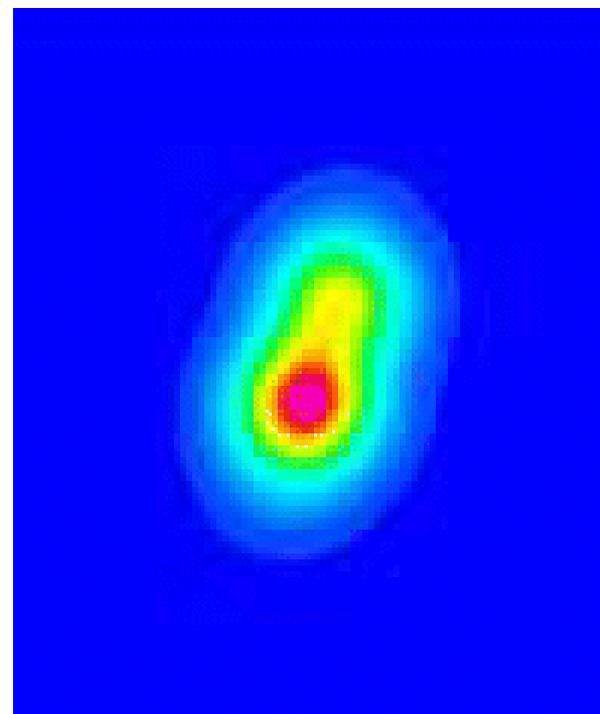




Алексей Семенов, с. Исаклы Самарской обл.

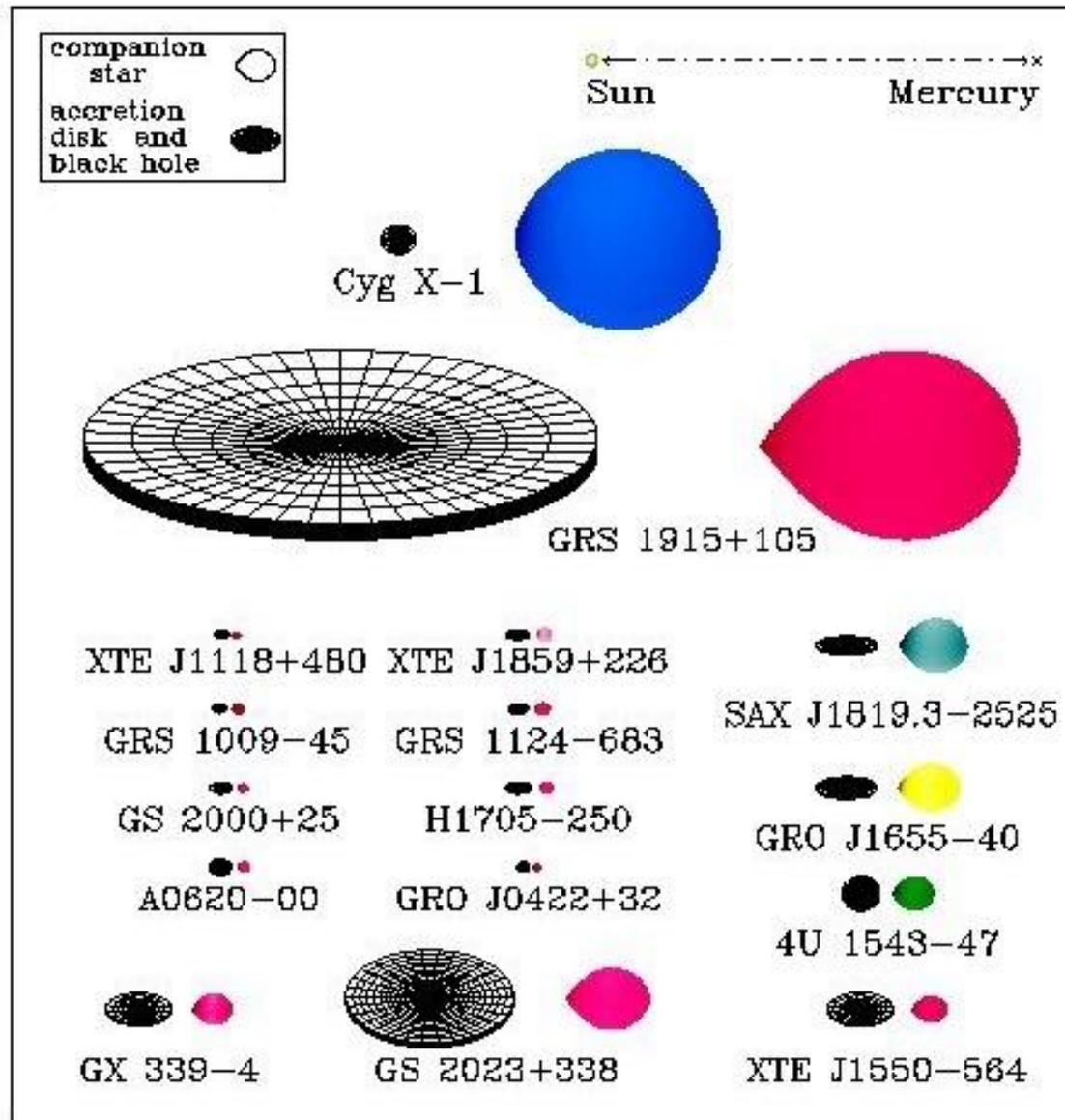






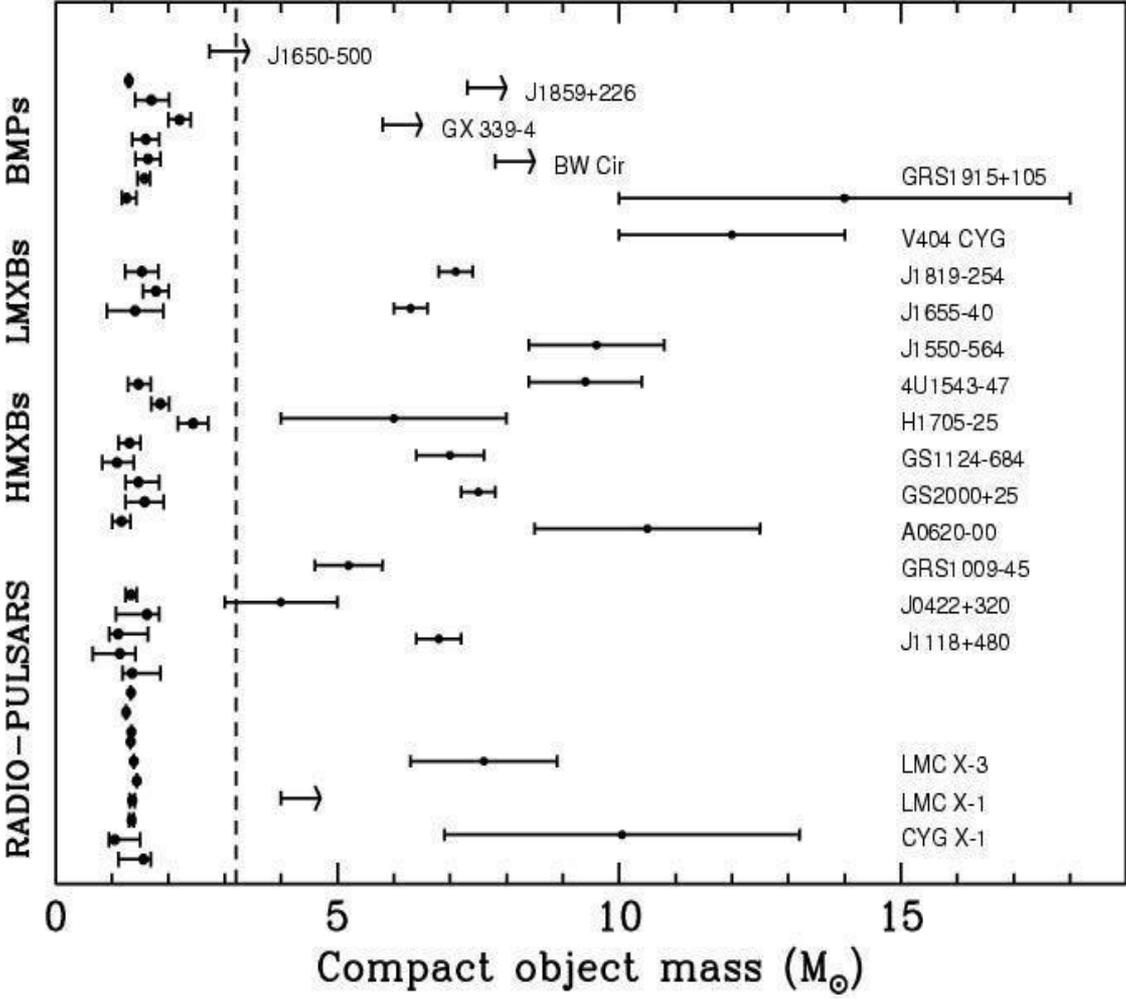
V4641 Sgr radio jet (J.Hjellming, VLA)
1999 Sep.16 30 min later 1999 Sep.17

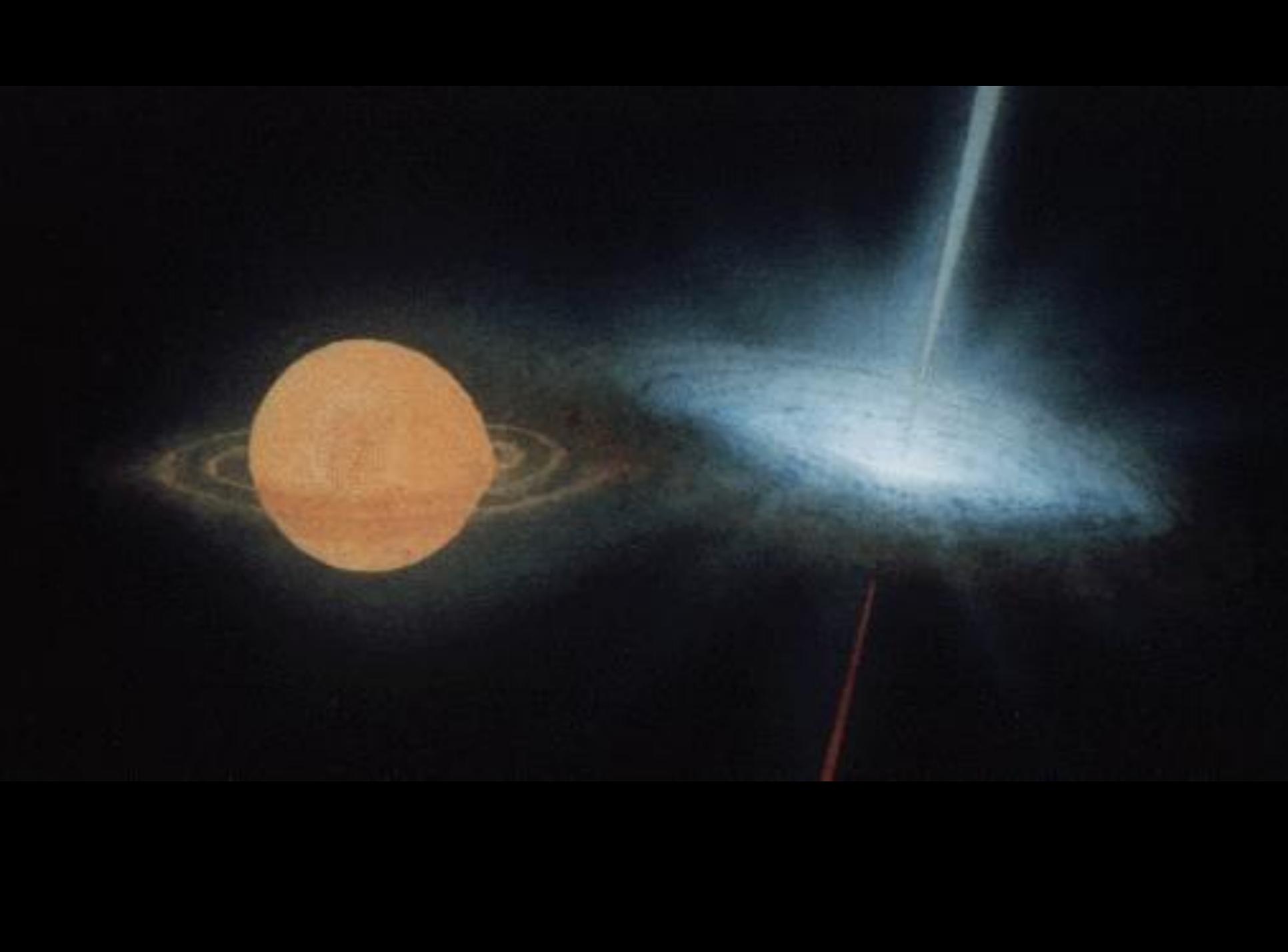
Black Hole Binaries in the Milky Way

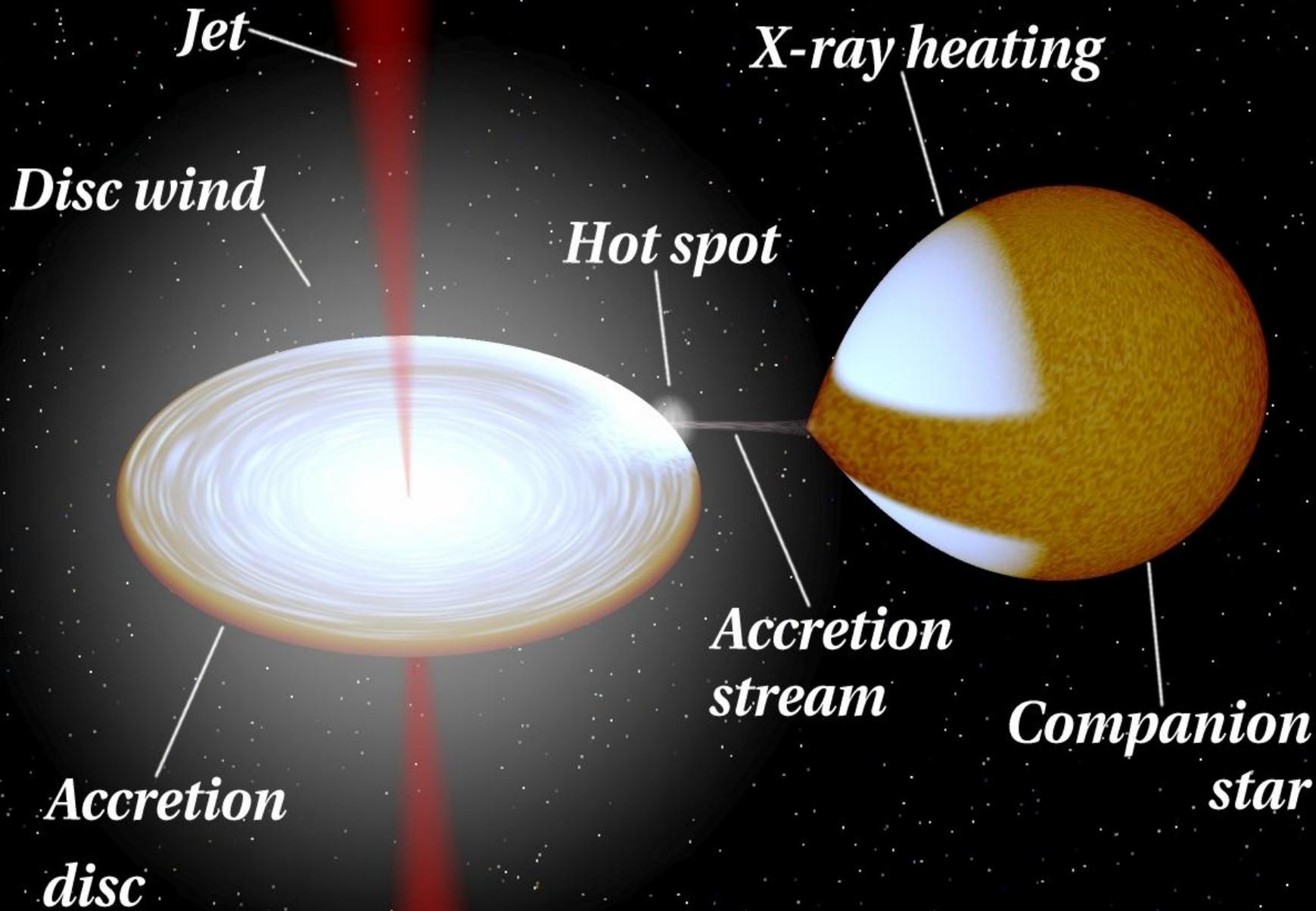


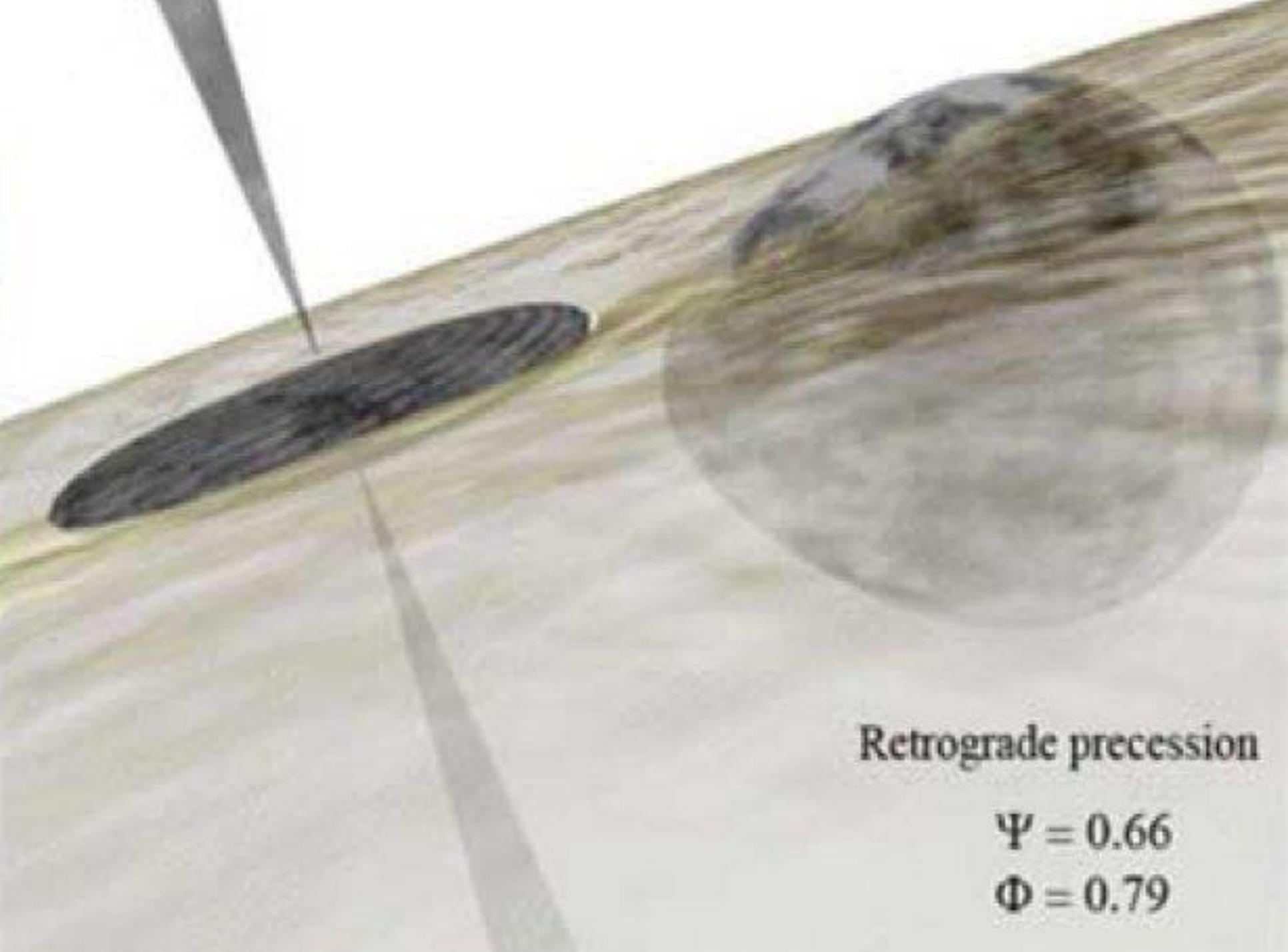
McClintock, Remillard, 2006

Распределение известных релятивистских звезд по массам





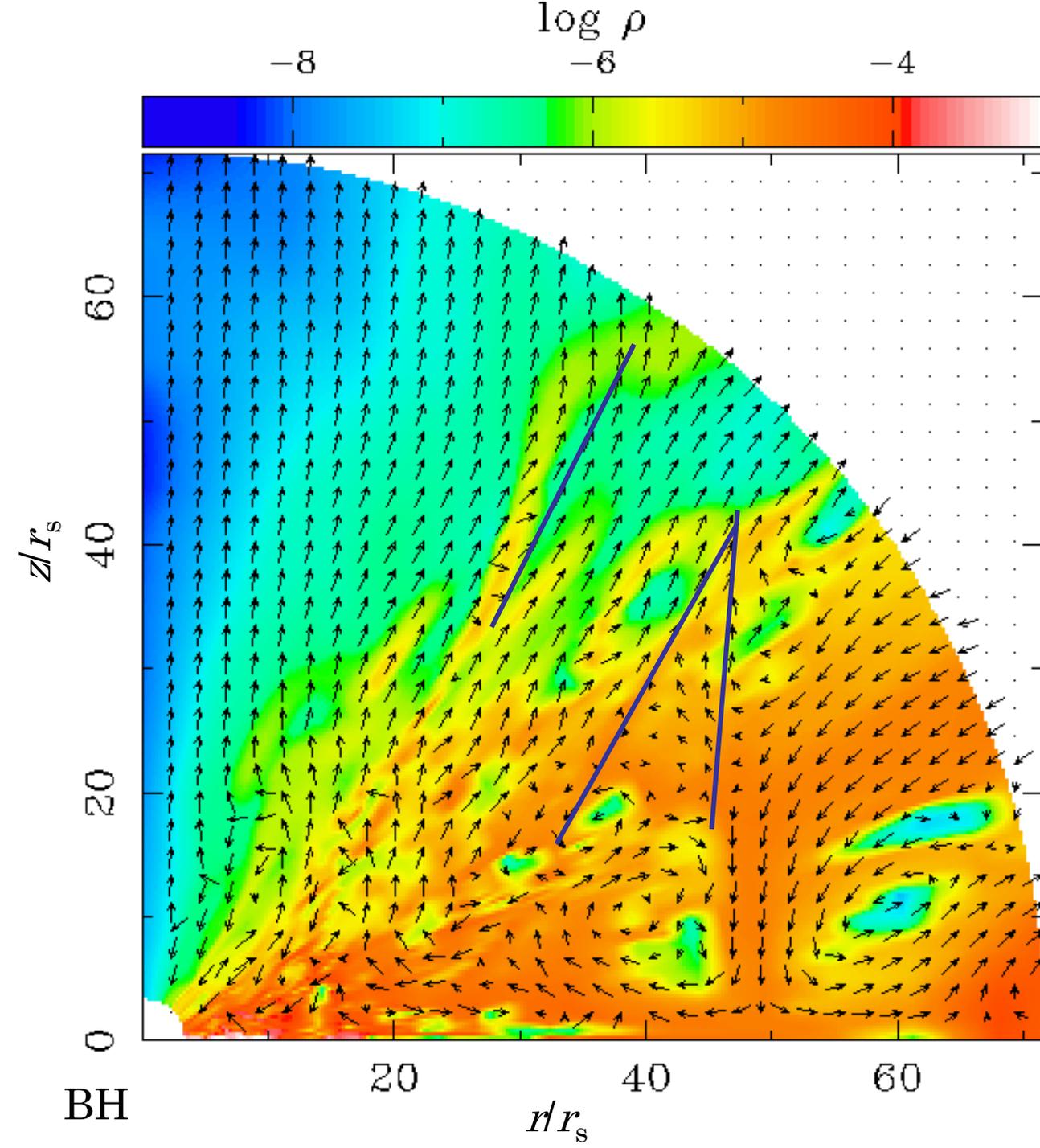




Retrograde precession

$$\Psi = 0.66$$

$$\Phi = 0.79$$



Сверхкритический
аккреционный диск

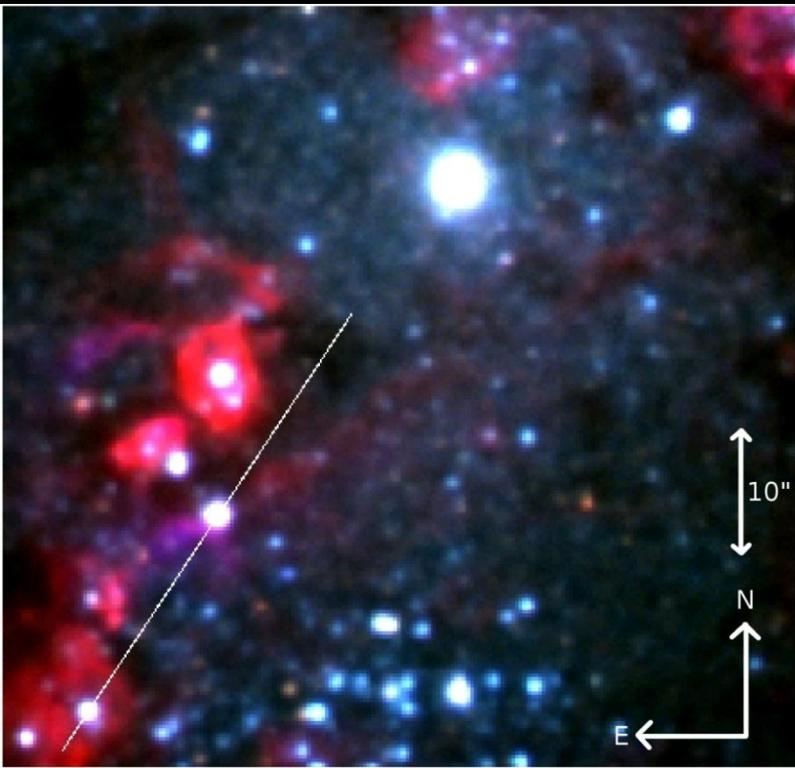








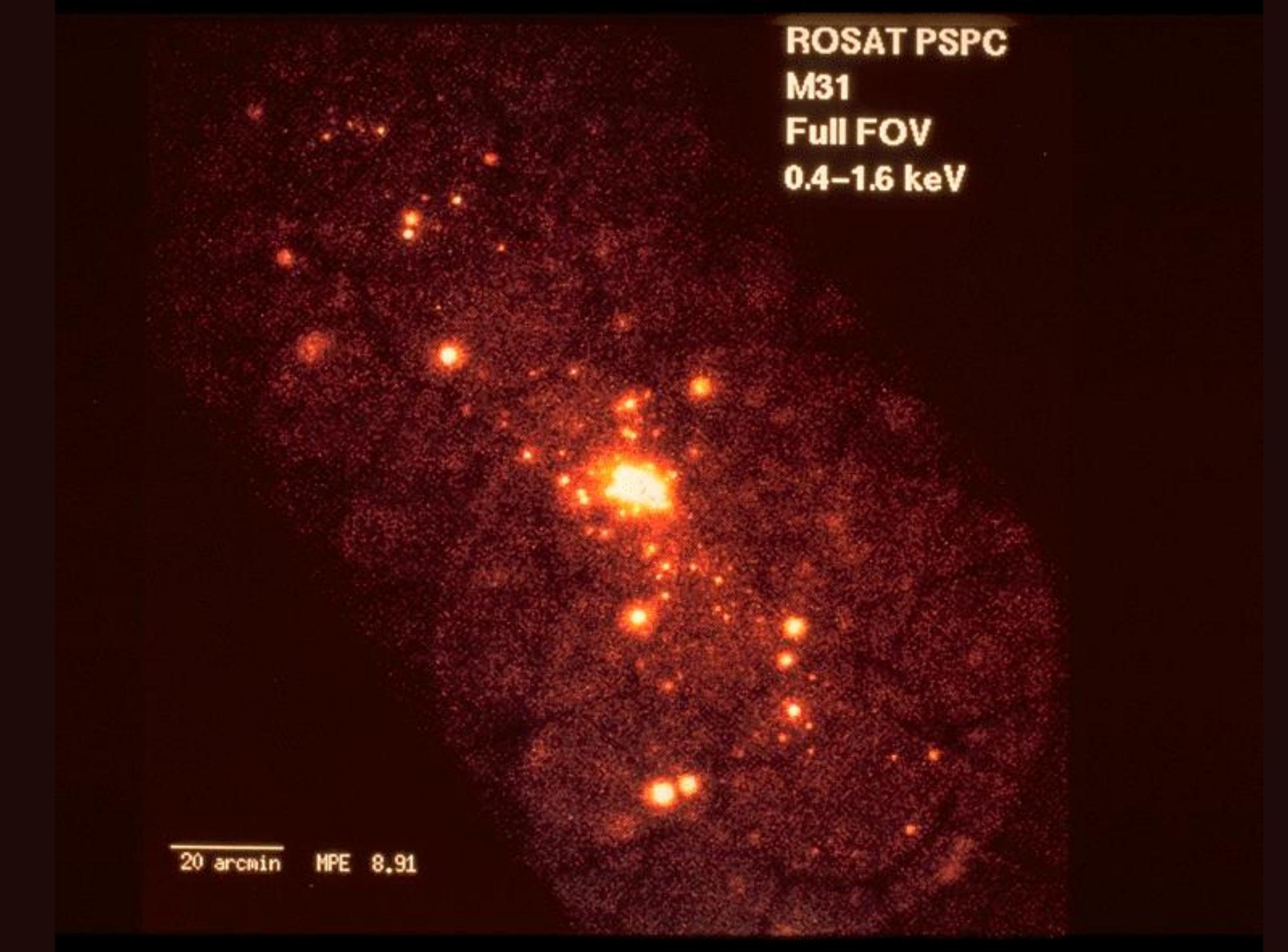
Ядро галактики M33



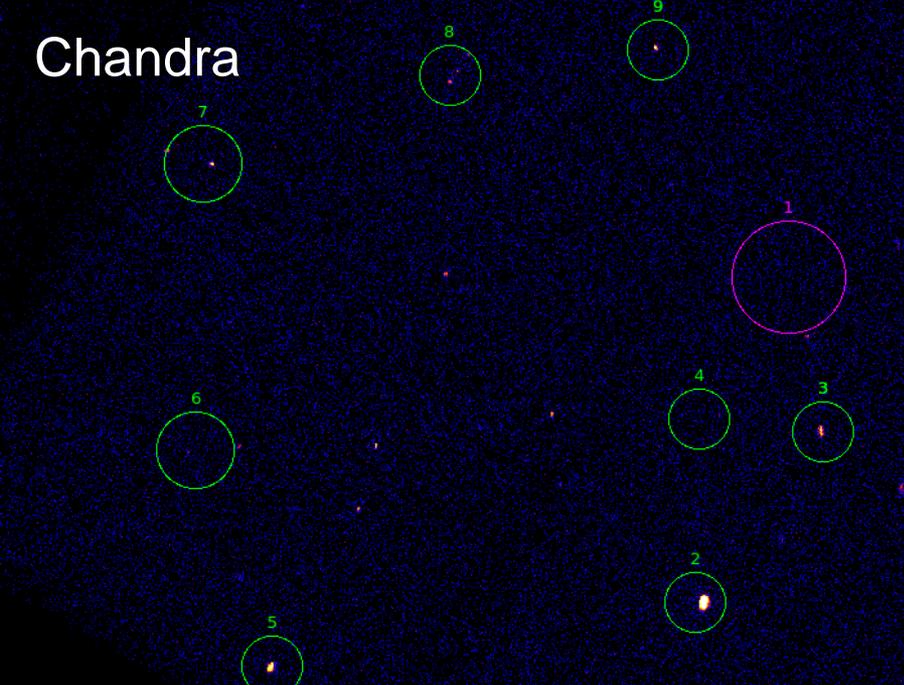
NGC6888 из звезды WR136

ROSAT PSPC
M31
Full FOV
0.4–1.6 keV

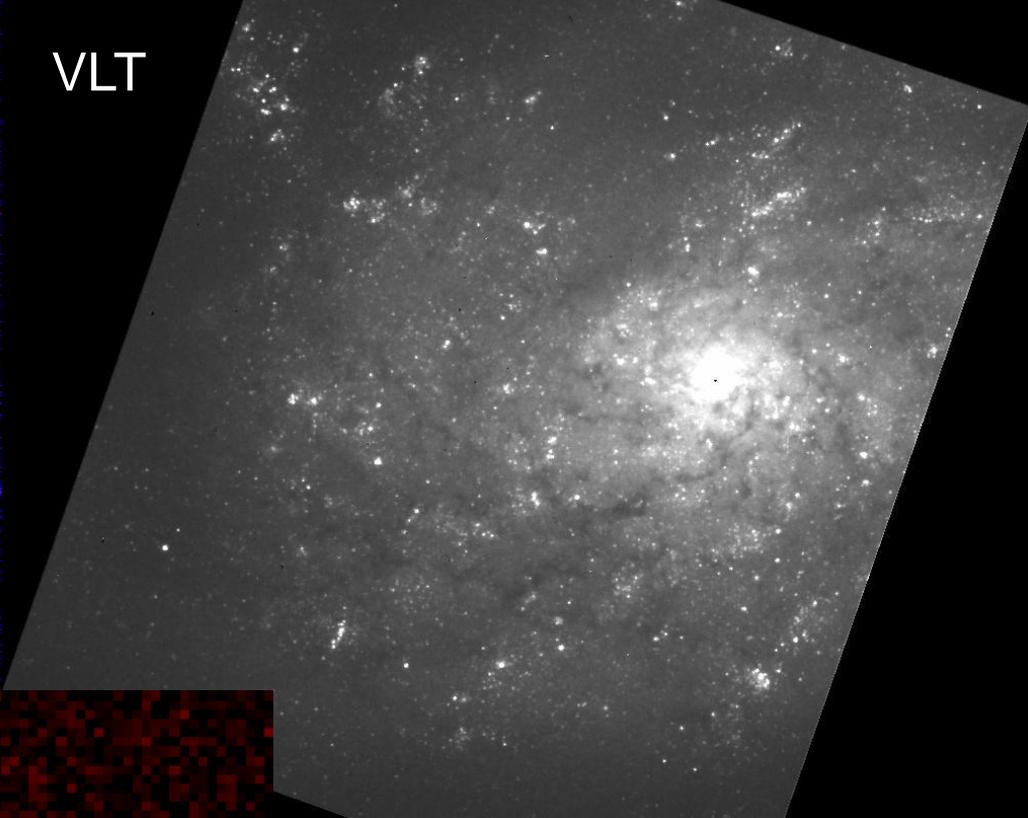
20 arcmin MPE 8.91



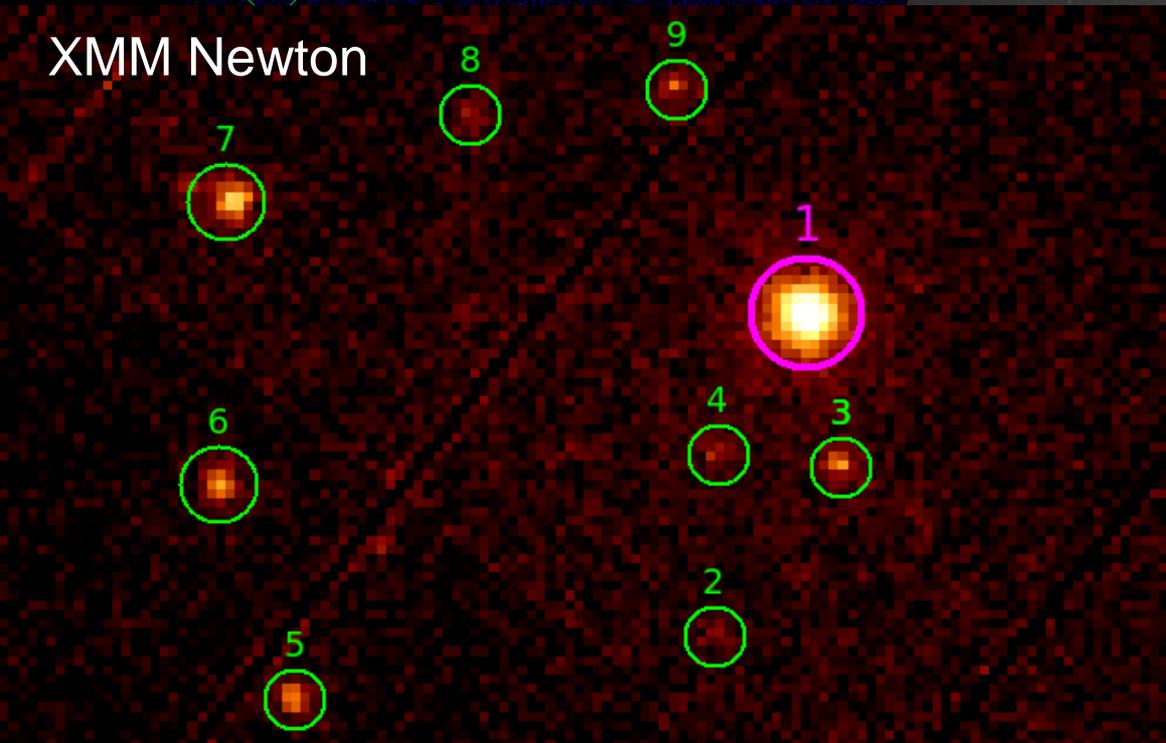
Chandra



VLT

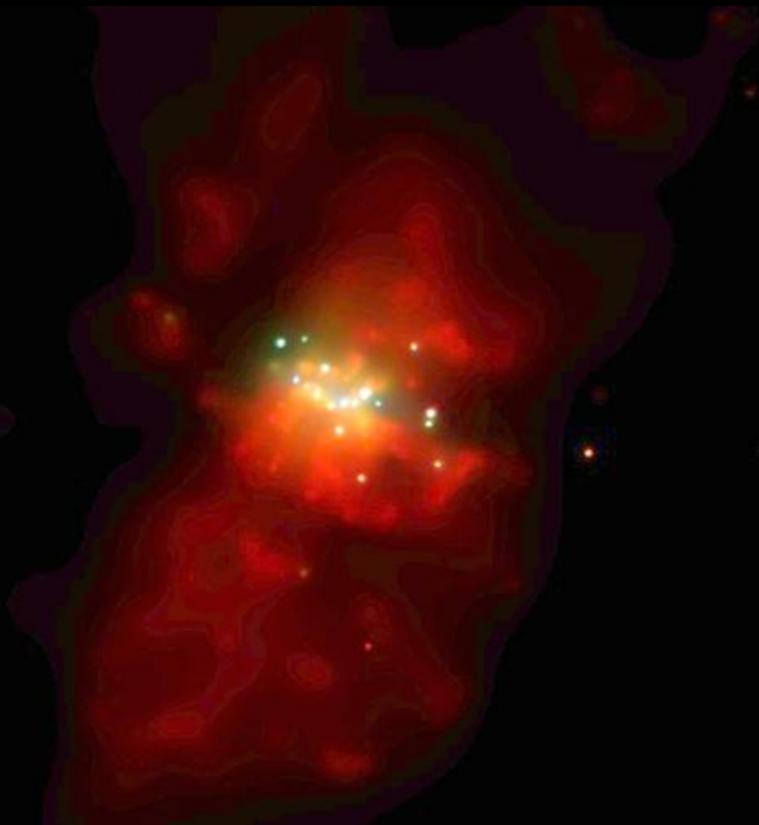


XMM Newton

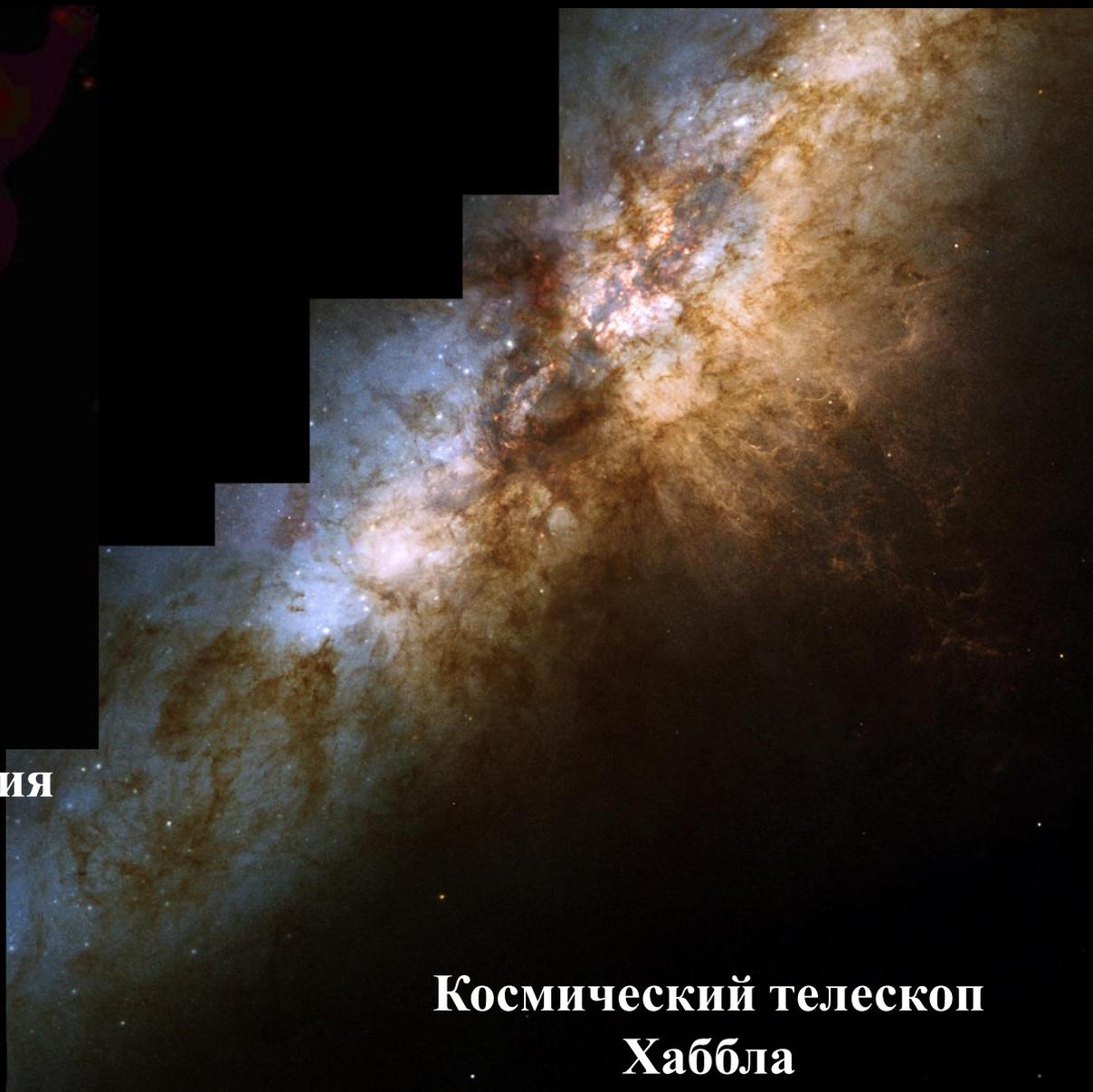


Черная дыра
в галактике NGC7793

Взаимодействующая галактика М82

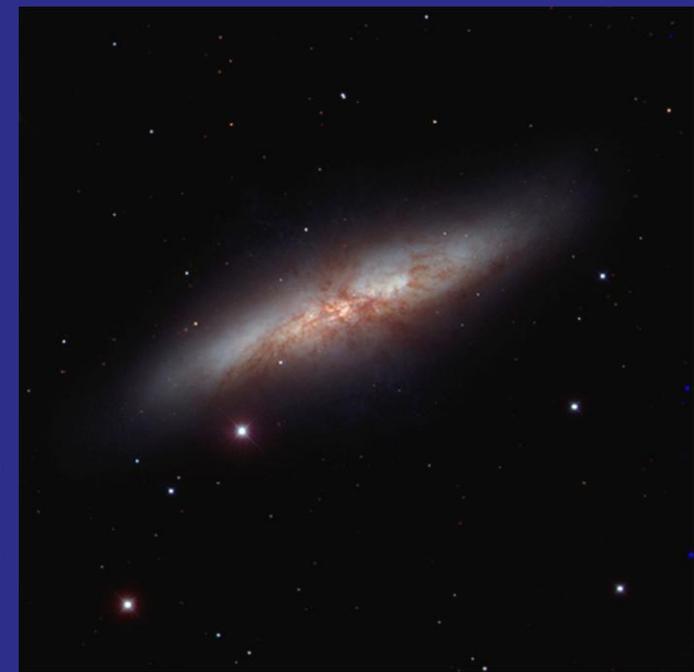
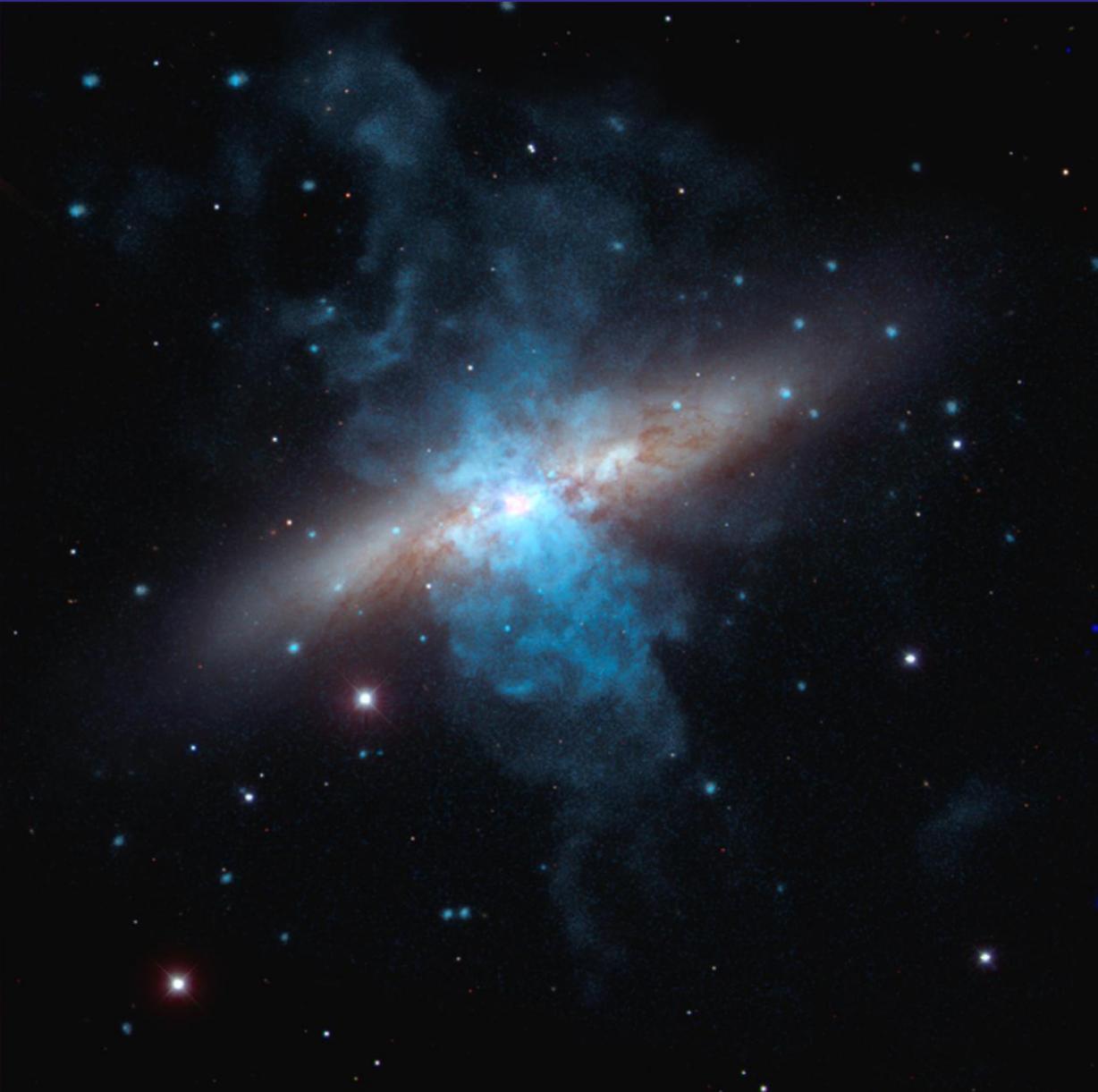


Рентгеновская обсерватория
Chandra

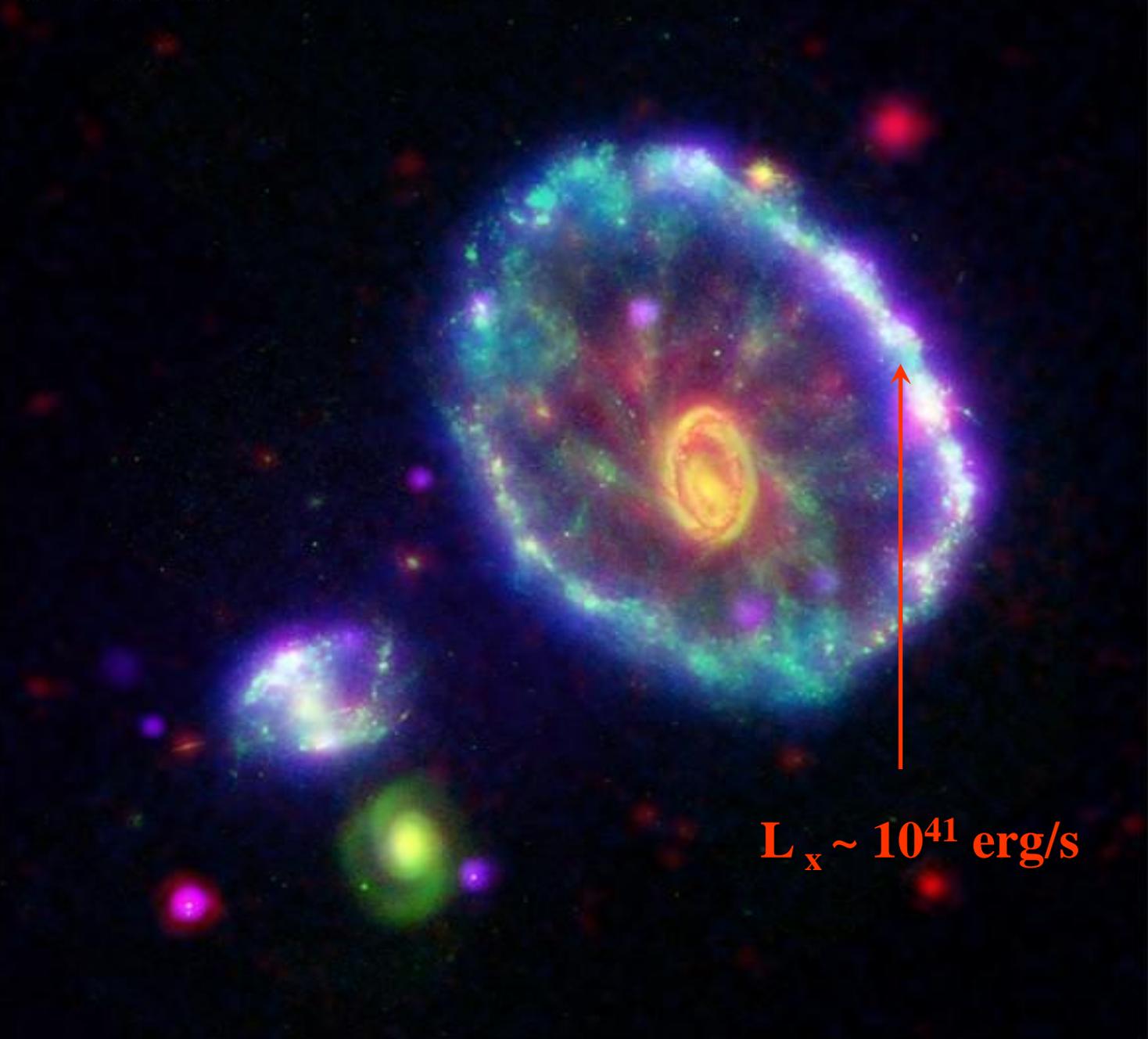


Космический телескоп
Хаббла

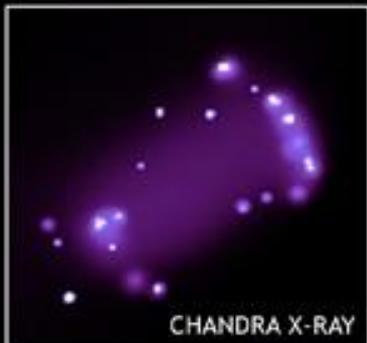
галактика M82, рентгеновские струи



CARTWHEEL GALAXY



$L_x \sim 10^{41}$ erg/s



CHANDRA X-RAY



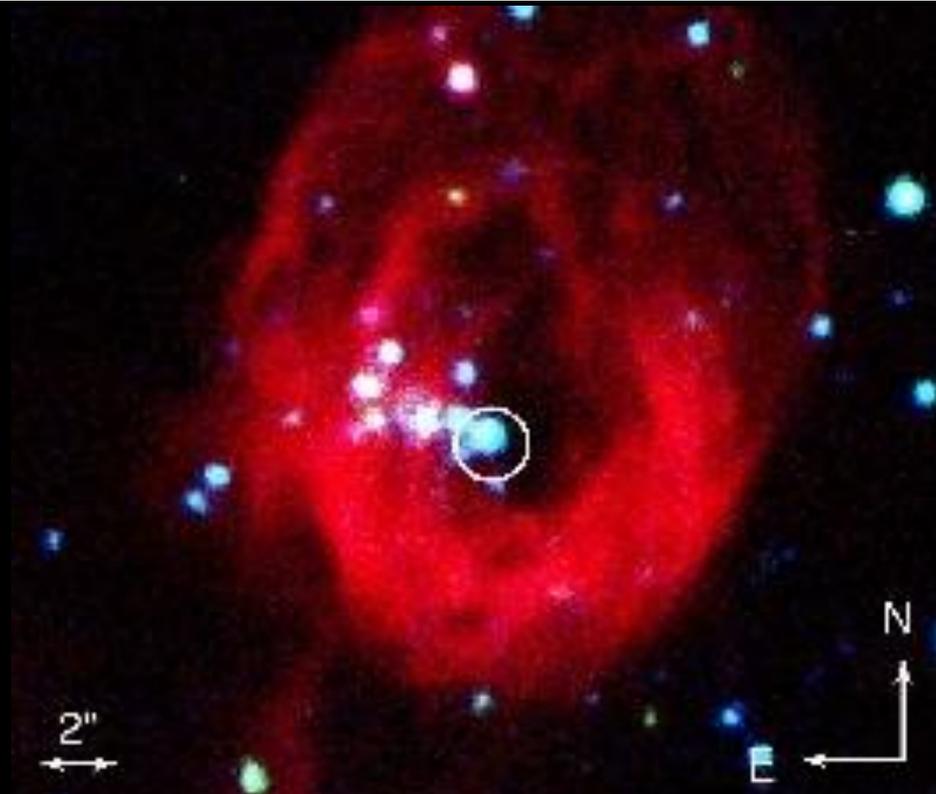
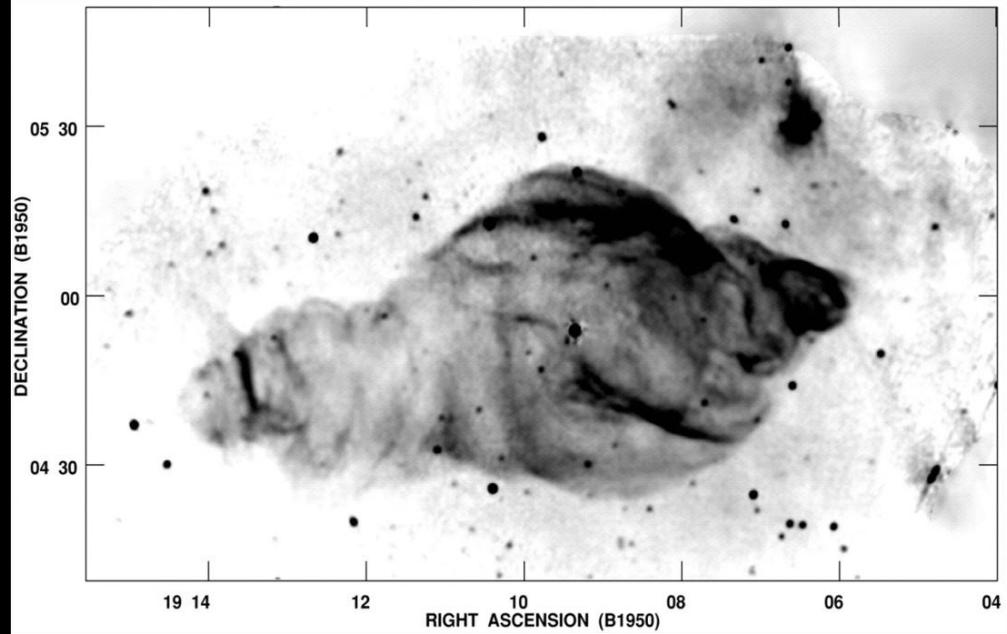
GALEX ULTRAVIOLET



HUBBLE VISIBLE

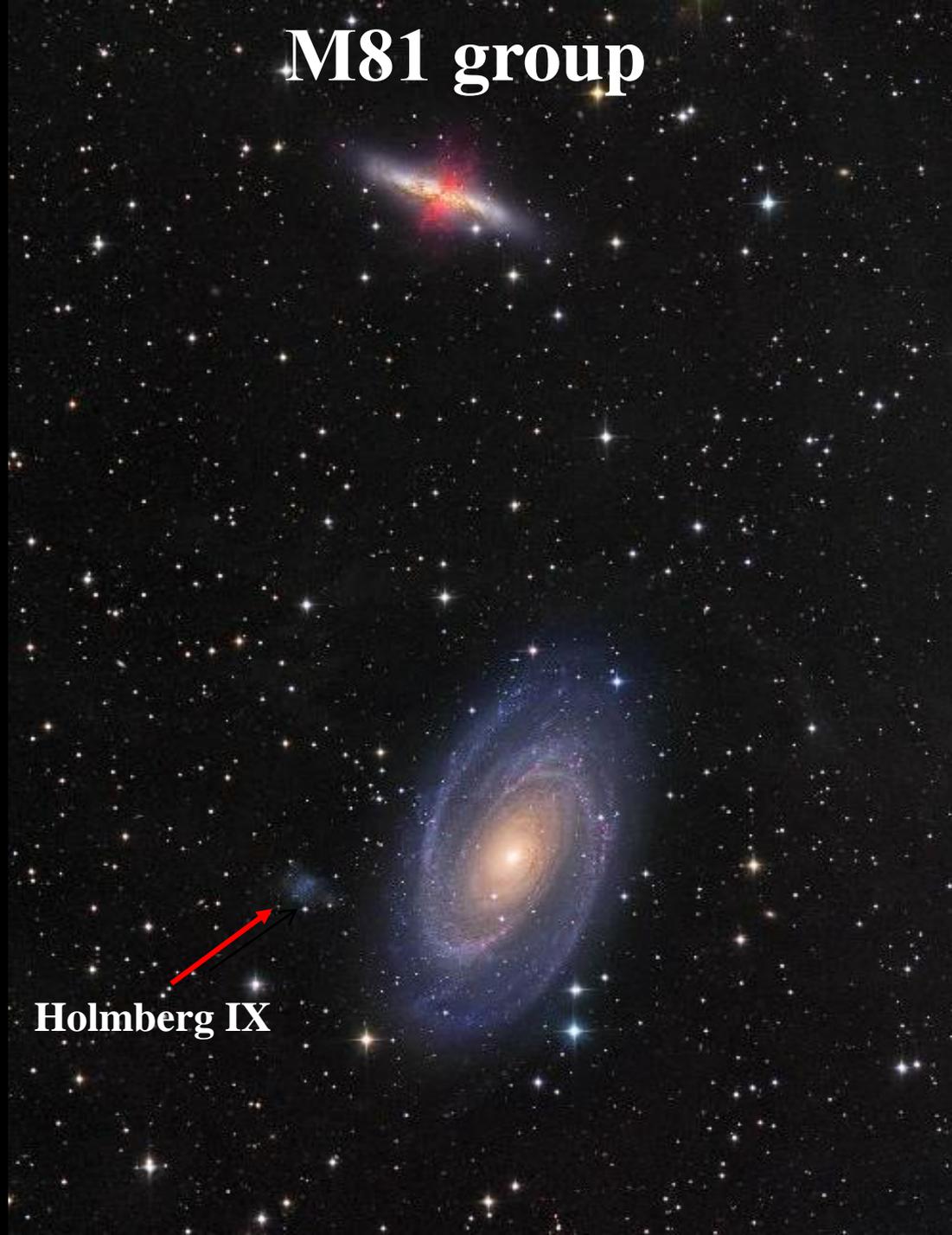


SPITZER INFRARED

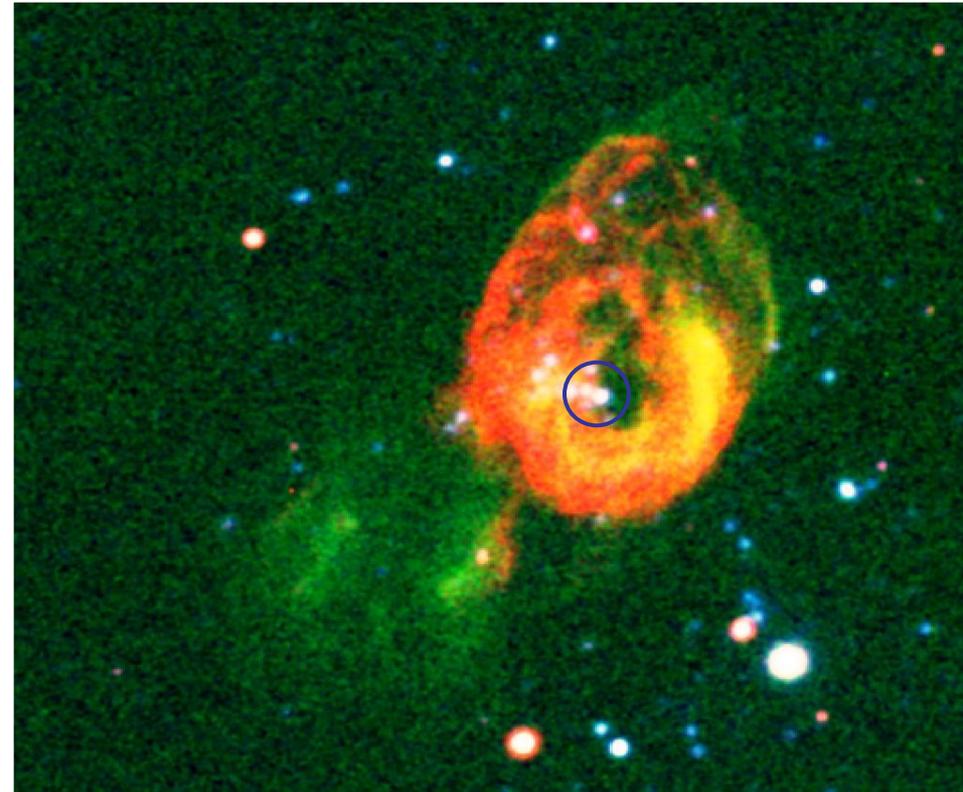
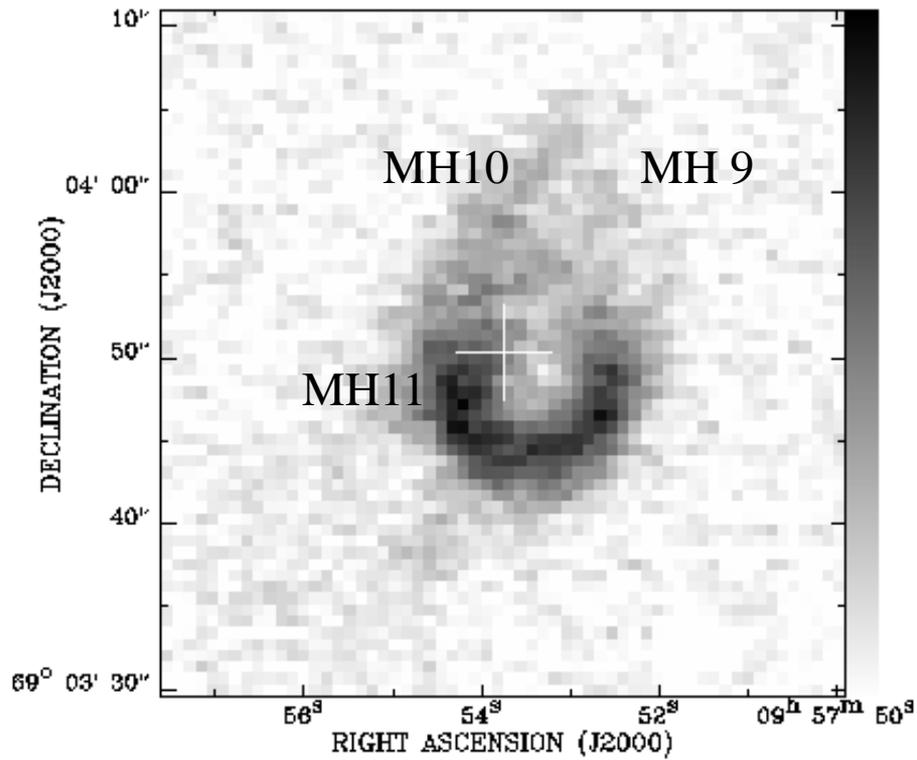


M81 group

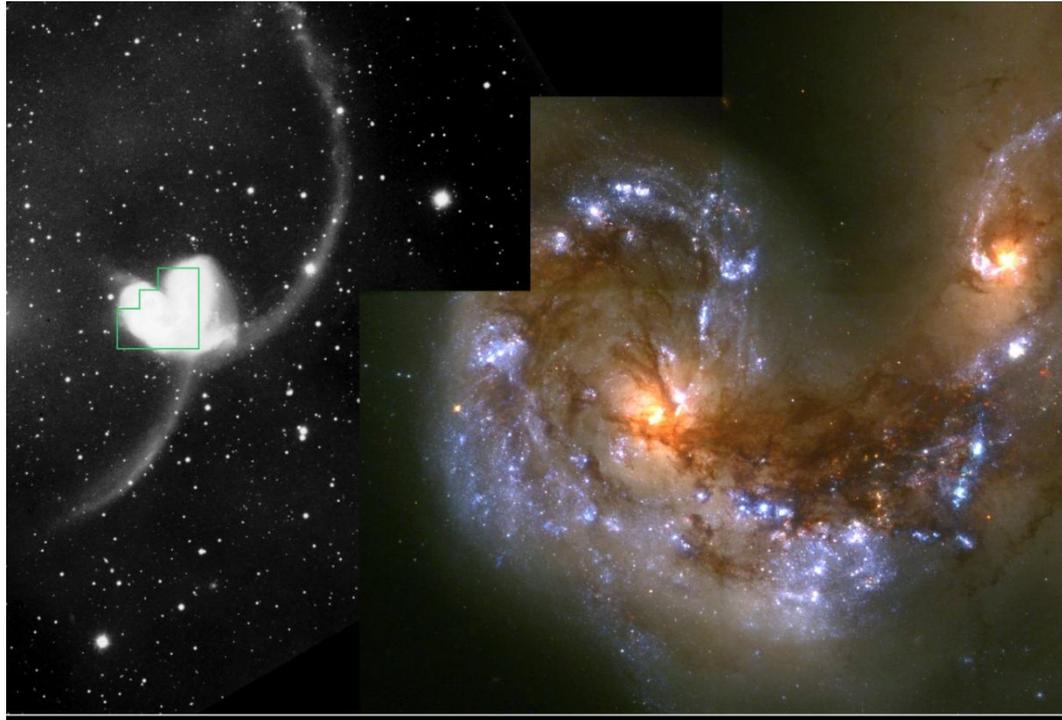
Holmberg IX



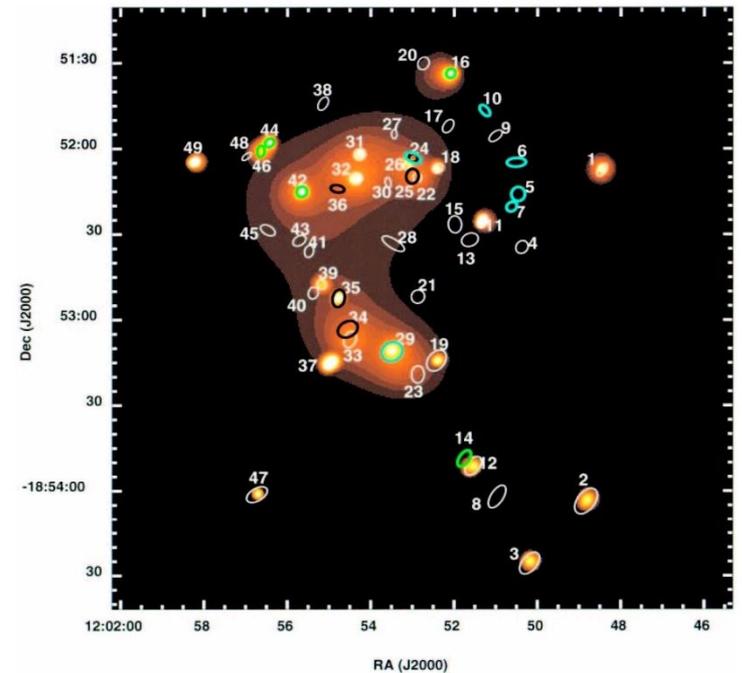
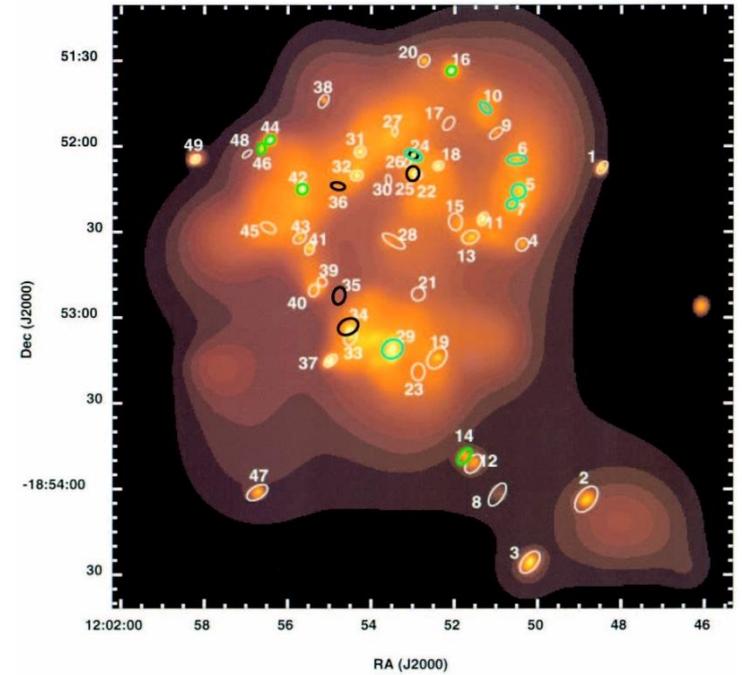
Галактика Holmberg IX, в туманности МН 9-11



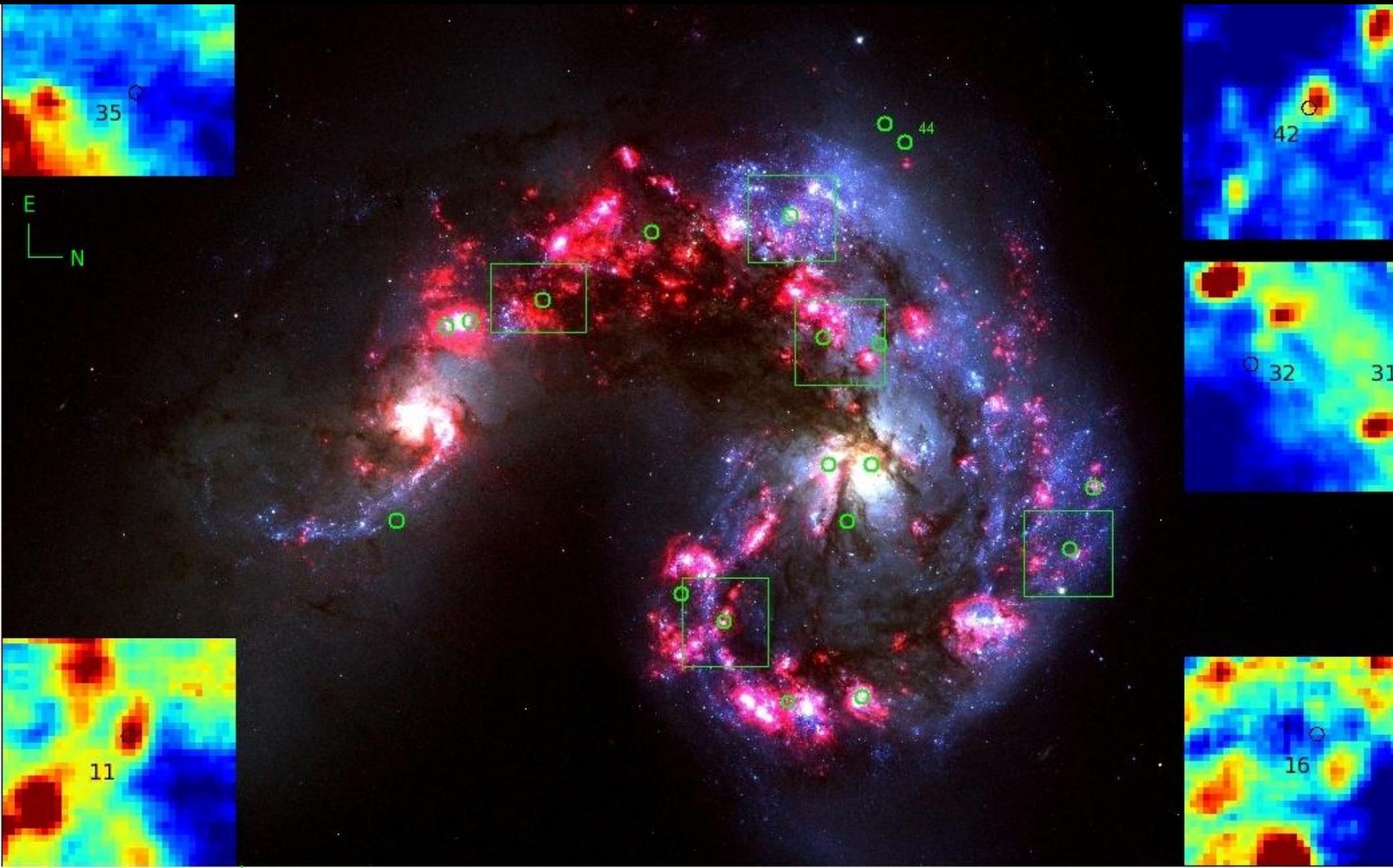
ULXs в галактиках Антенны Chandra (Zezas et al., 2002)



Colliding Galaxies NGC 4038 and NGC 4039
Hubble Space Telescope • Wide Field Planetary Camera 2



Antennae



ULXs в Антеннах



Они не в скоплениях