

Quasar e Buchi Neri

Maria Massi

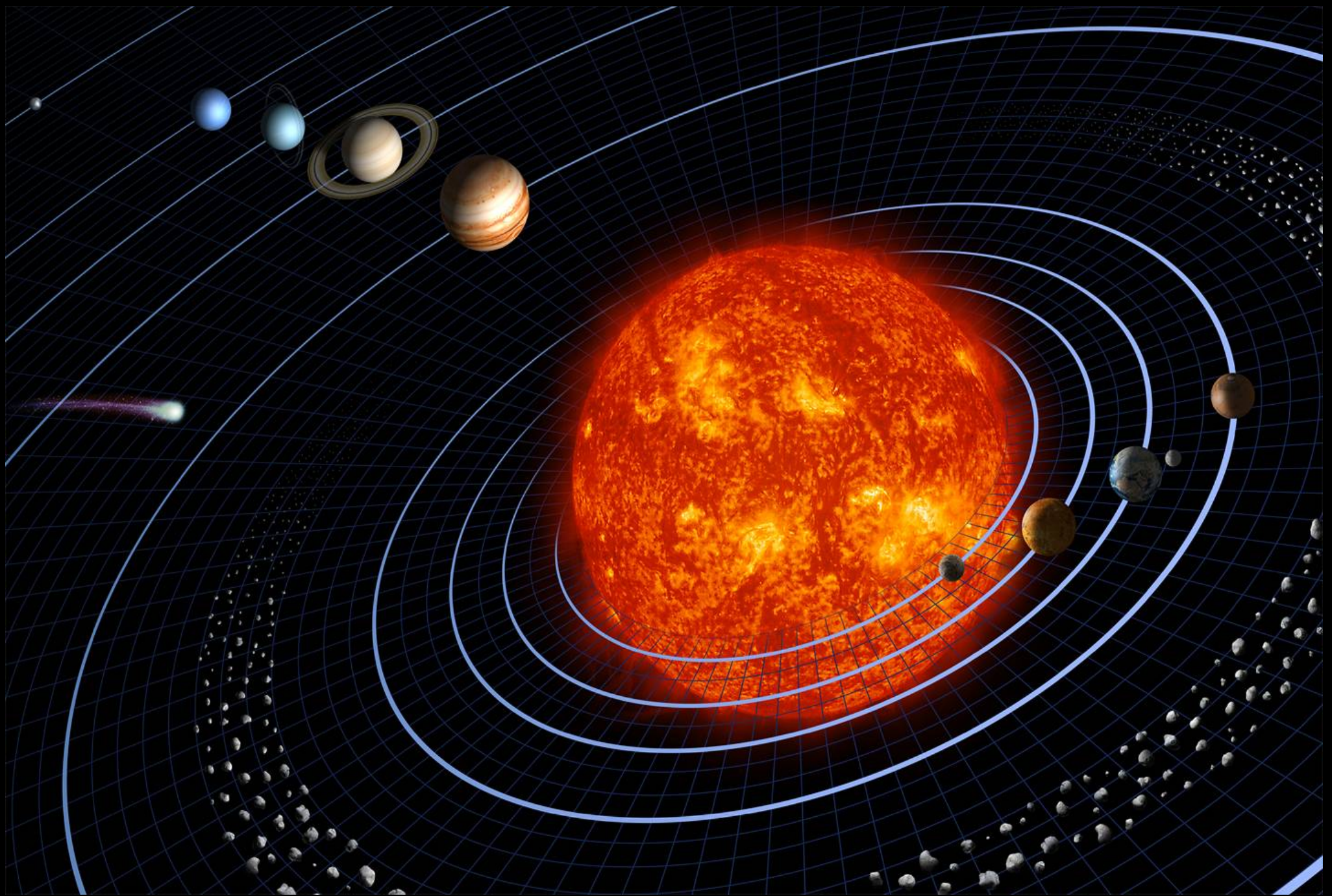
(Max Planck Institut für Radioastronomie)



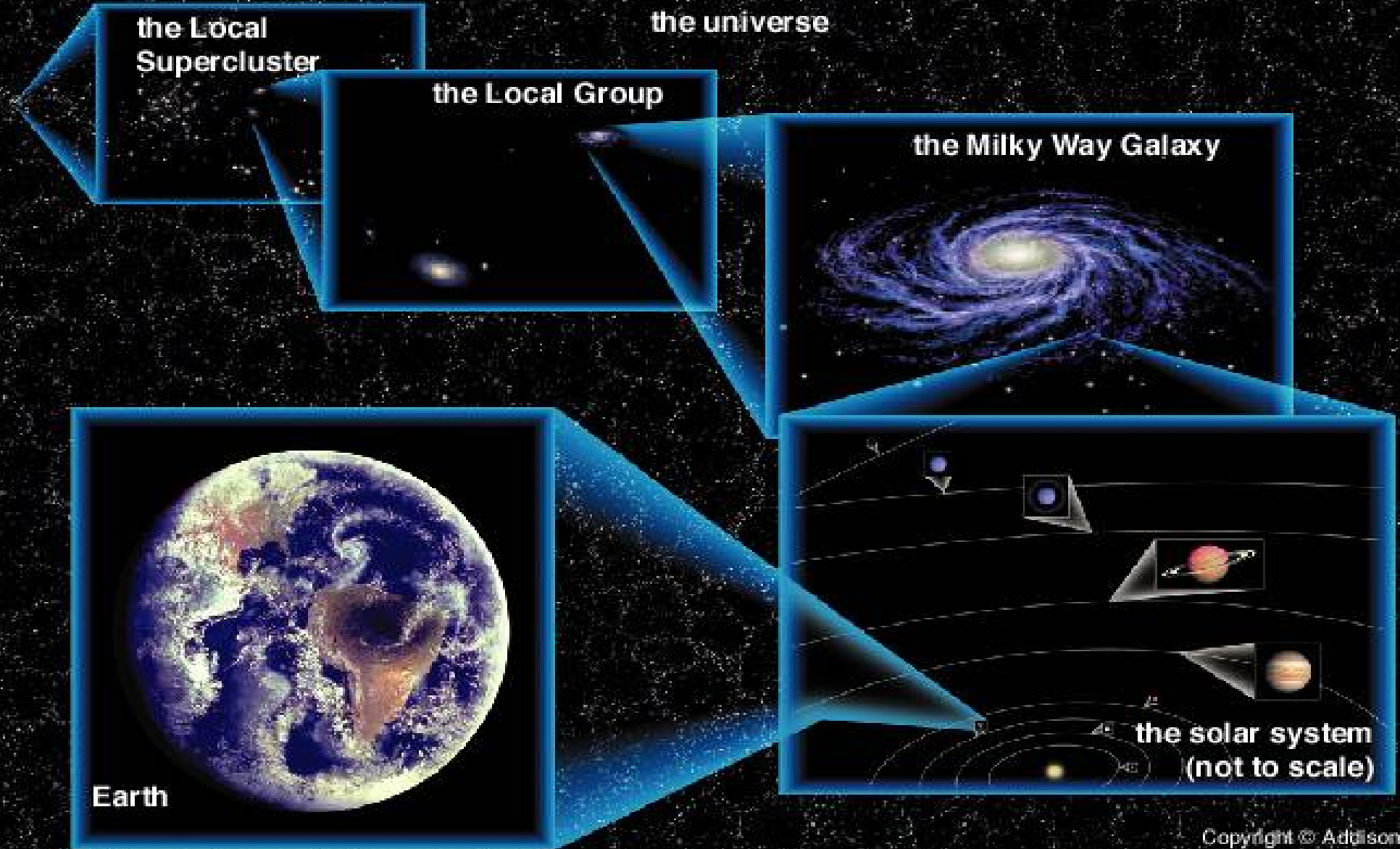
I Quasar sono gli oggetti piu' luminosi dell' Universo



- I. Come sono stati scoperti i Quasar ?
- II. Cosa e' un Quasar ?
- III. Cosa resta dopo la fase “Quasar” ?



Il nostro punto di partenza: La terra



Copyright © Addison Wesley

La Via Lattea : una delle 35 Galassie del gruppo Locale.
La distanza della Terra dal centro del superammasso della Vergine:45 milioni di anni luce.
I Quasar distano dalla Terra miliardi di anni luce.

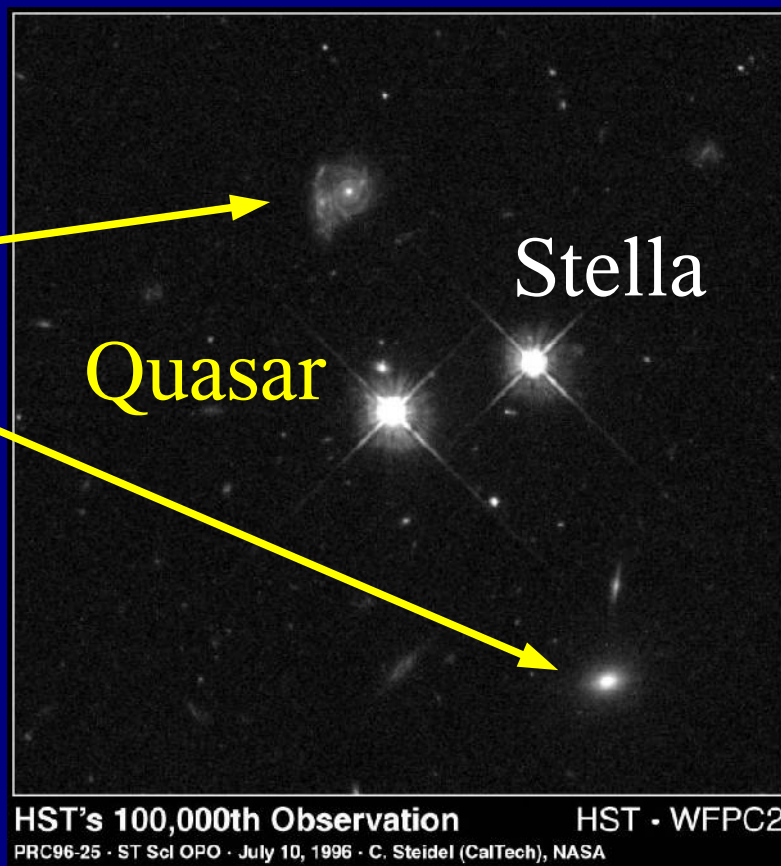
Astronomia Ottica



Galassie

Quasar

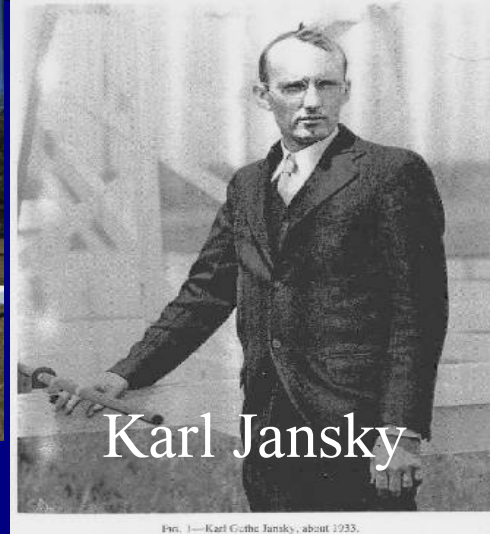
Stella



Radioastronomia

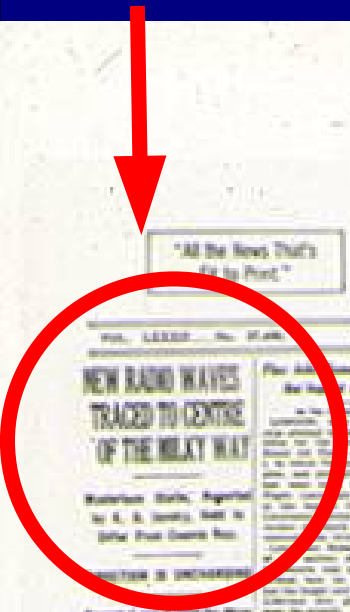
5. Mai 1933

Onde radio dal centro della
Via Lattea



Karl Jansky

FIG. 1—Karl Gertie Jansky, about 1933.



The New York Times.

LATE-CITY EDITION

NEW YORK, FRIDAY, MAY 5, 1933.

NEW RADIO WAVES TRACED TO CENTRE OF THE MILKY WAY

WASHINGTON, May 4.—(AP)—Radio waves from the center of the Milky Way galaxy have been traced by Karl G. Jansky, of the National Bureau of Standards.

Dr. Jansky, who is in charge of the radio astronomy section of the bureau, said that he had discovered the waves while making observations of the radio signals from the stars.

He said that the waves were of a frequency of about 21 million cycles per second, and that they were of a strength of about 100,000 times that of the ordinary radio signals from the stars.

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BIG NEW DIVISION PLANNED BY JAPAN ON ROAD TO PEKING

Large-scale offensive that has been planned in Japan to take place in the near future.

Japanese officials are reported to have announced that they are planning a large-scale offensive against the Chinese government.

The offensive is said to be planned for the near future, and is expected to be a major blow to the Chinese government.

It is said that the Japanese government is planning to take advantage of the current situation in China to launch a major offensive.

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ROOSEVELT ASKS PAY RISE FOR WORKERS; PROMISES TO HELP BUSINESS END CHAOS; HE SENDS RAILROAD BILL TO CONGRESS

WASHINGTON, May 4.—(AP)—President Roosevelt today asked Congress to raise the pay of federal workers, and promised to help business end chaos.

He also sent a bill to Congress to increase the pay of railroad workers.

The bill is said to be a major step in the effort to end the chaos in the railroad industry.

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Features of Railroad Bill

WASHINGTON, May 4.—(AP)—The bill to increase the pay of railroad workers, which President Roosevelt sent to Congress today, has several features.

One of the features is that it will increase the pay of railroad workers by 10 percent.

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PRESIDENT TELLS IF GOES

WASHINGTON, May 4.—(AP)—President Roosevelt today told Congress that he would support the bill to increase the pay of railroad workers.

He said that the bill was a major step in the effort to end the chaos in the railroad industry.

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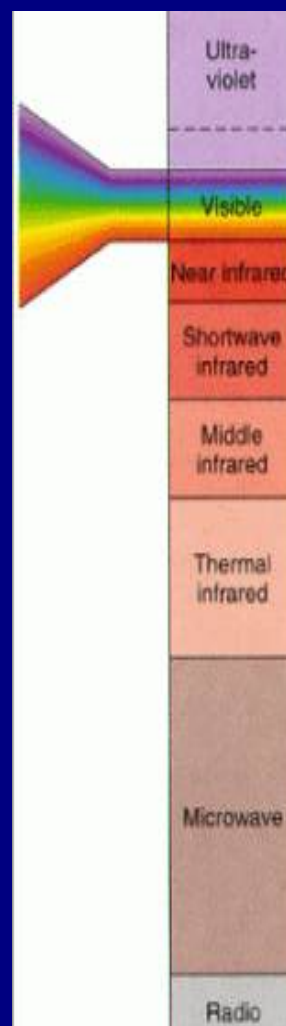
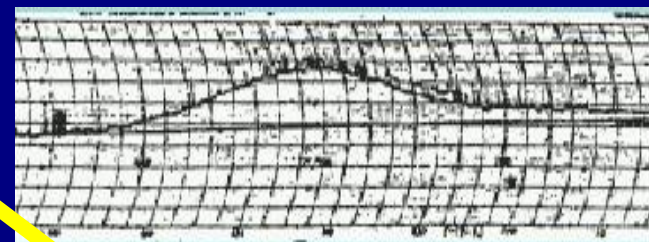
BRITISH DEMANDING ITALIANS NOW BACK
TARIFF SAFEGUARDS BRITISH ARMS PLAN

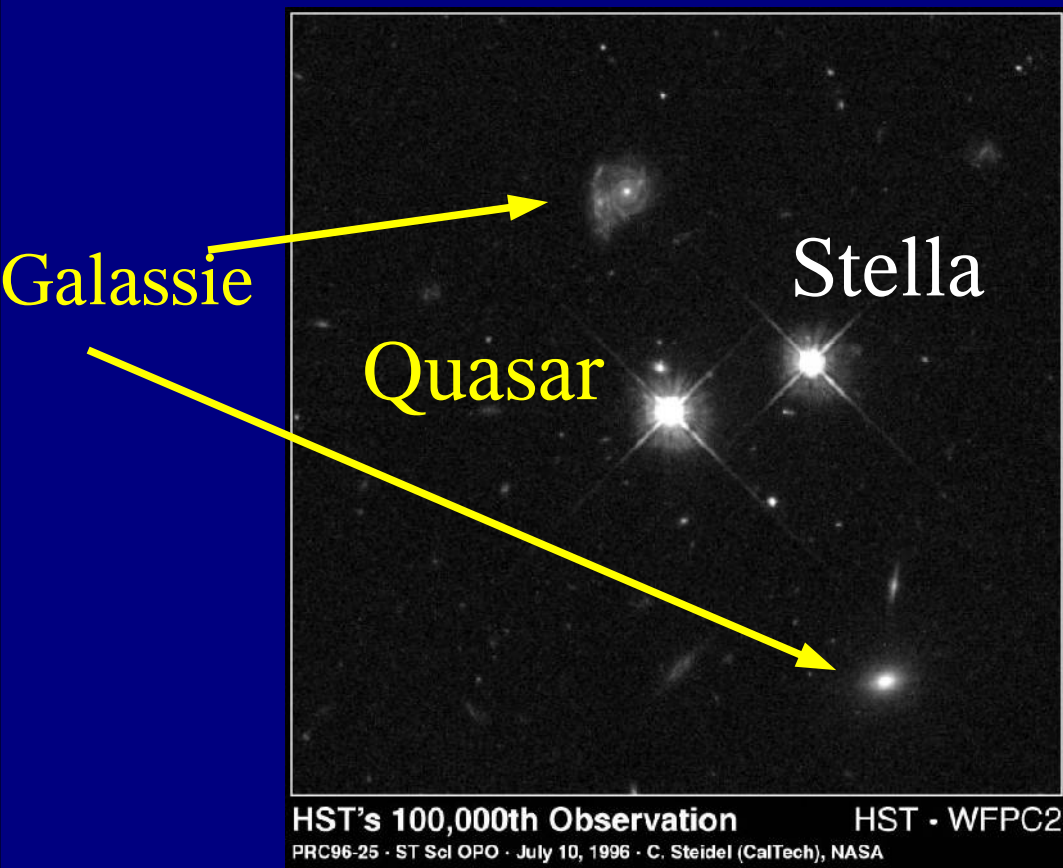
Catalogo di Cambridge

200 sorgenti radio

Inizia l' Era delle IDENTIFICAZIONI

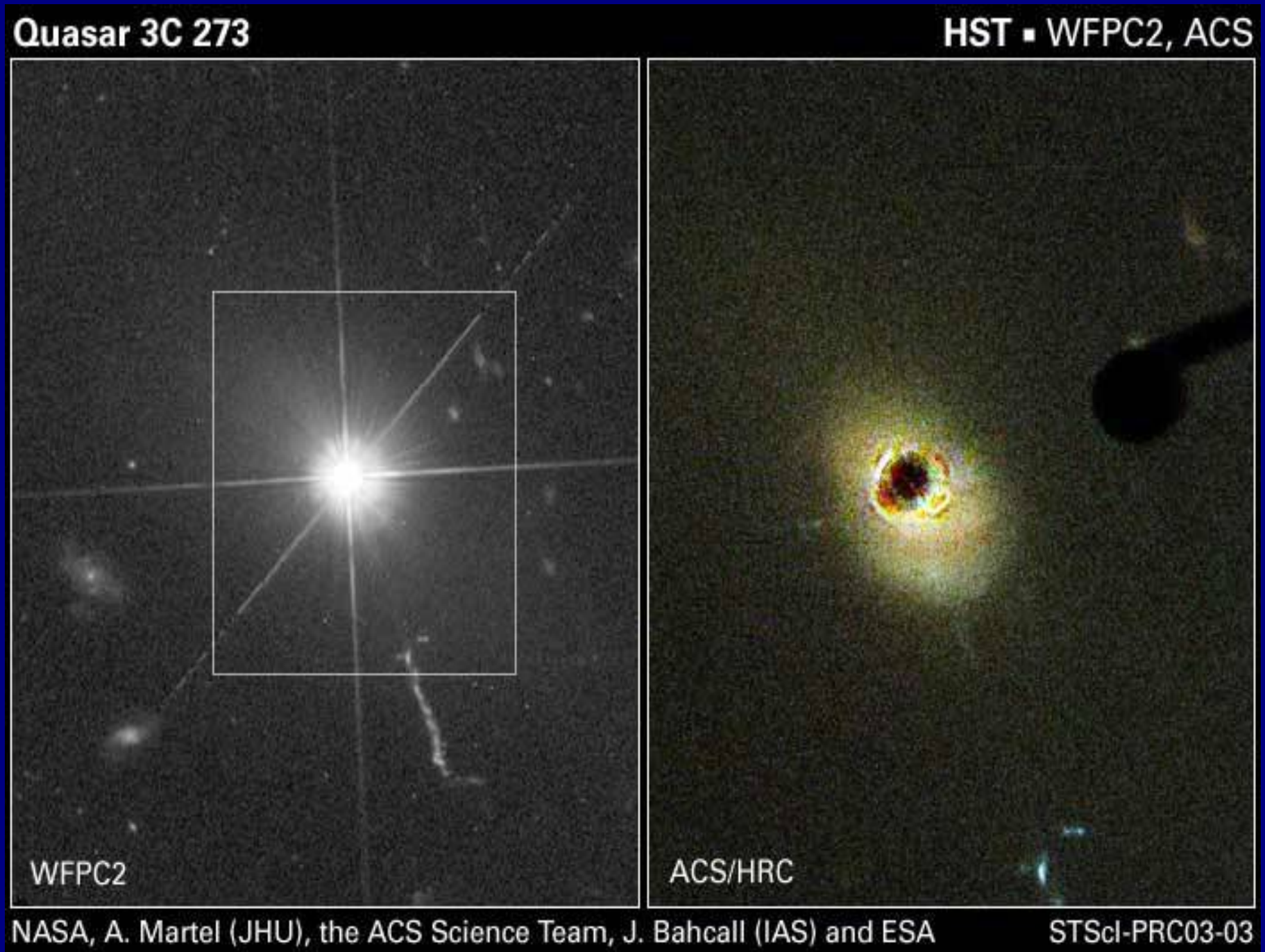
?



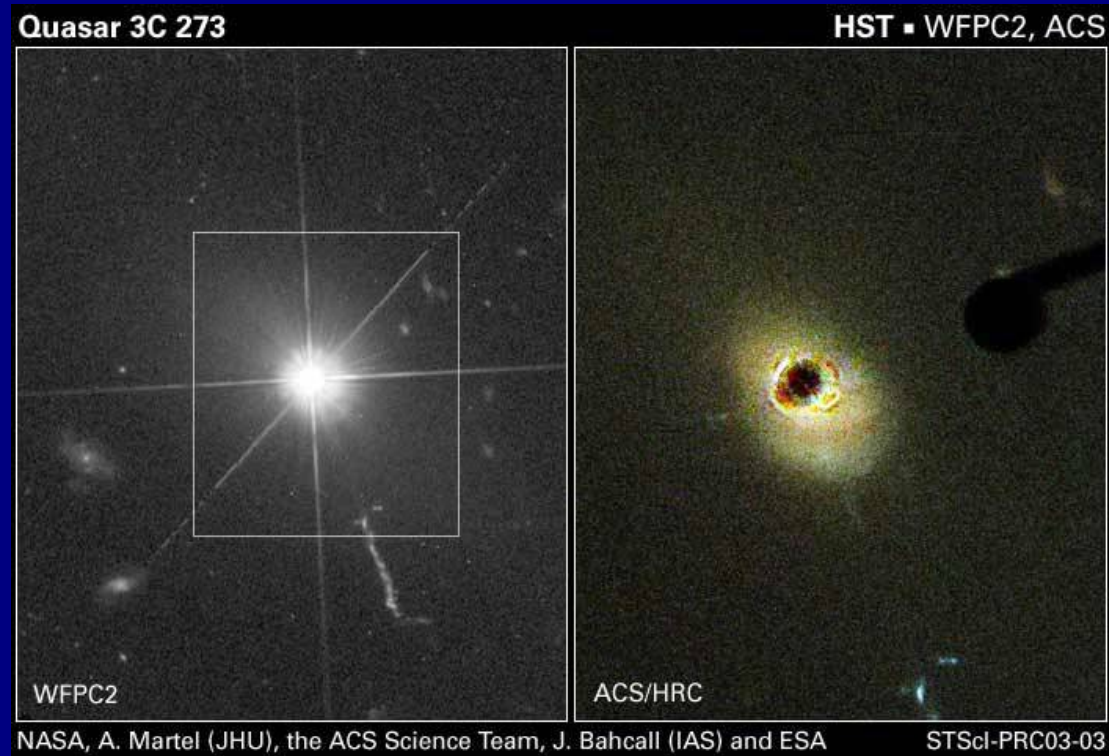


Oggetto quasi-stellare radio = QUASAR
emittente

... un salto ad oggi: il telescopio Hubble



$$\frac{L_{\text{Quasar}}}{L_{\text{Galassia}}} \sim 100$$

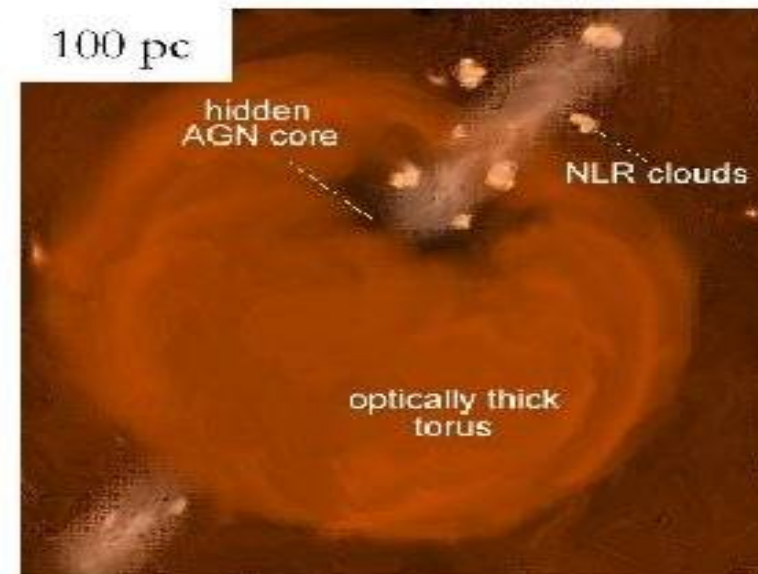
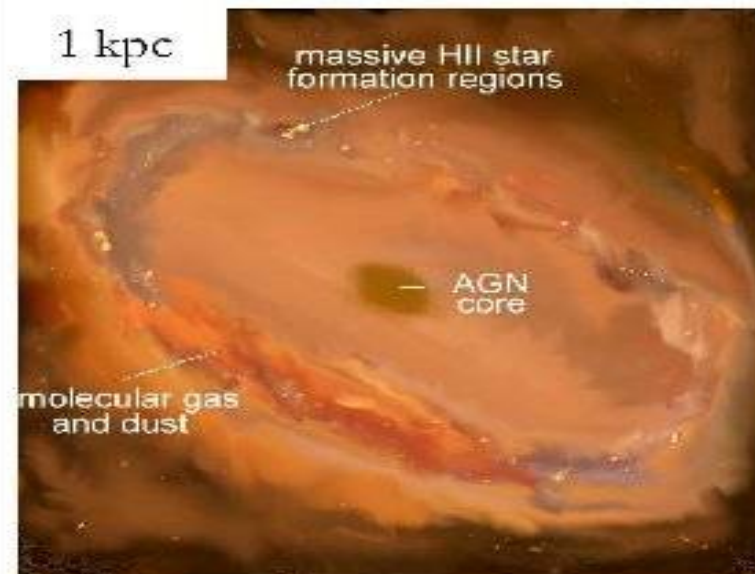
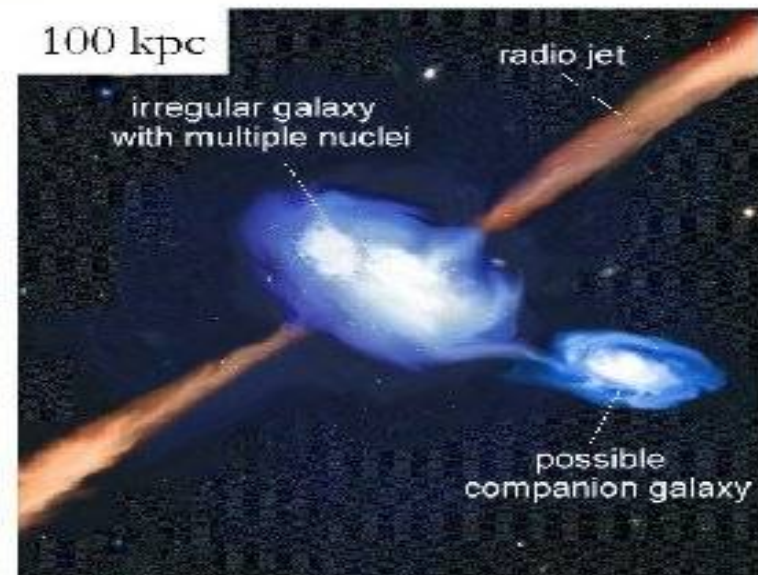
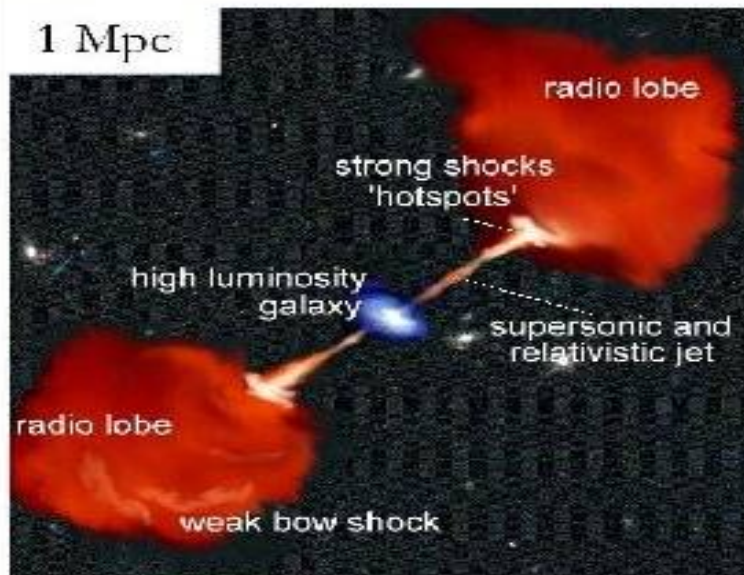


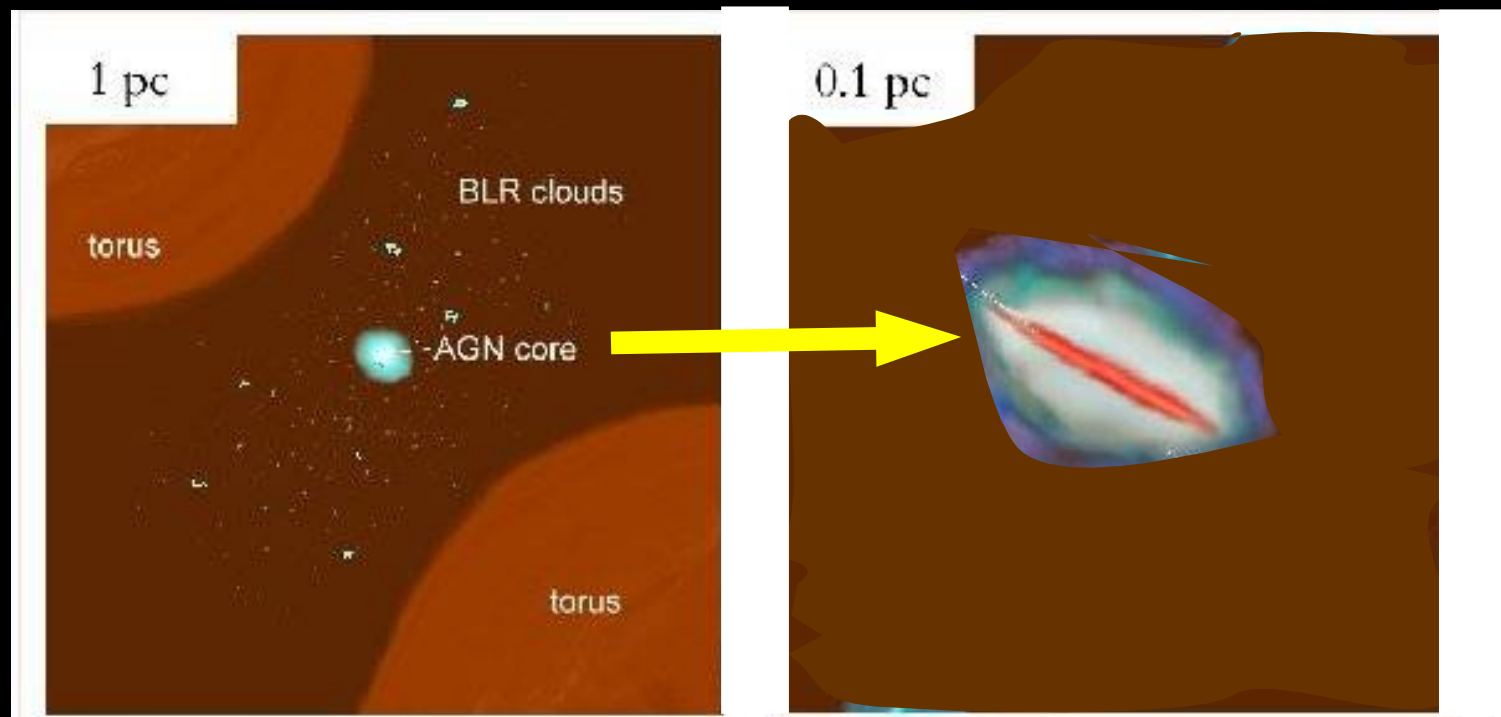
Dalla variabilita' si deducono dimensioni confrontabili col nostro sistema solare:

Da dove viene questa enorme energia localizzata in un cosi' piccolo volume ?

II. Cosa e' un Quasar ?

Viaggio in una galassia contenente un Quasar

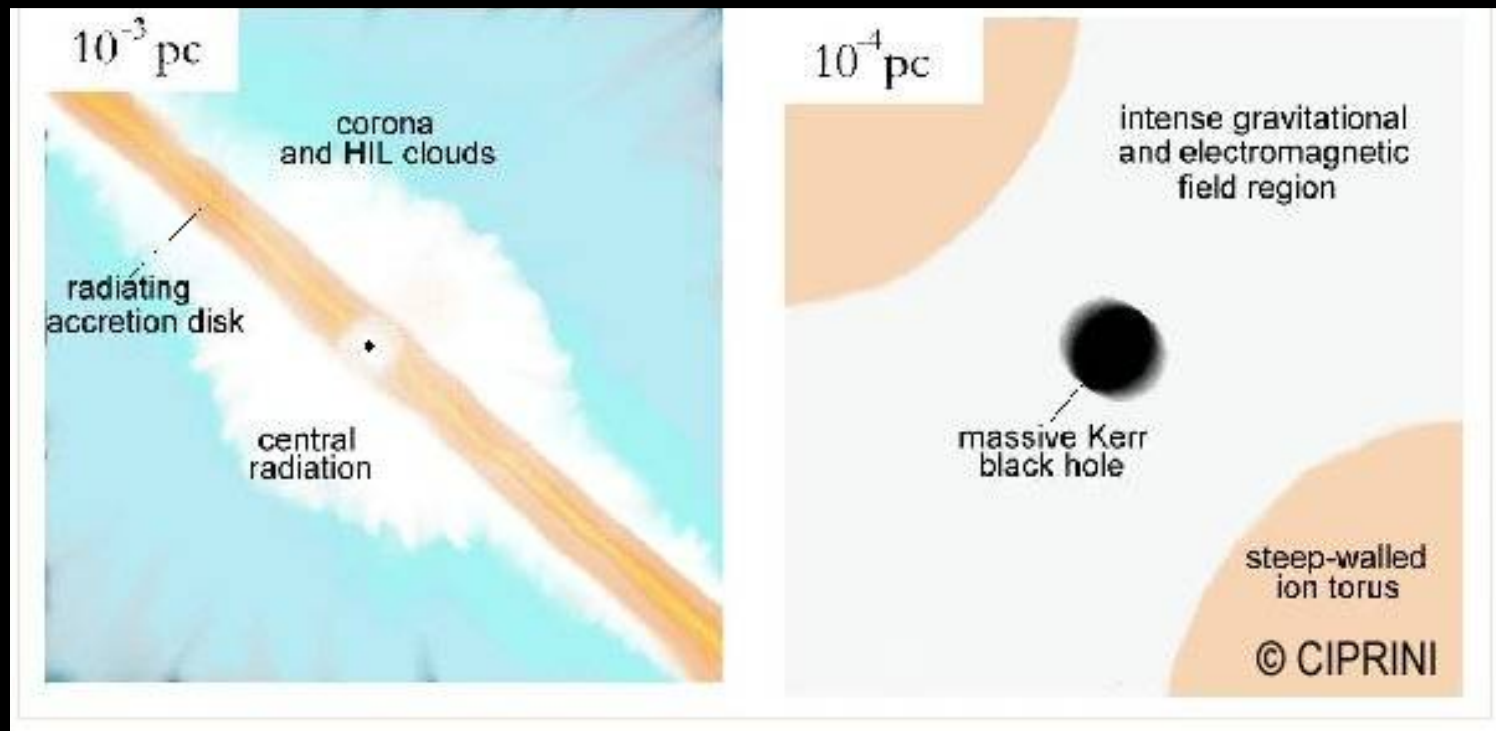




Ciprini

Al centro del disco si trova “il motore” del Quasar:

Un Buco Nero



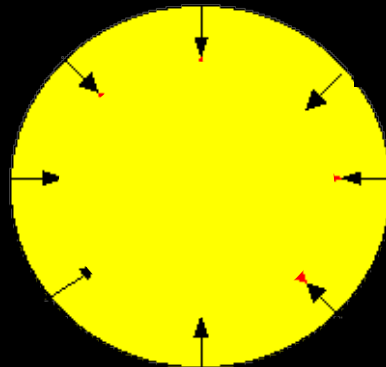
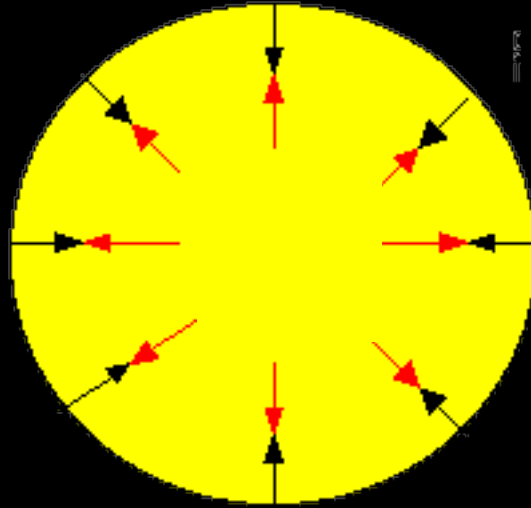
Buchi neri supermassicci (Miliardi di masse solari)

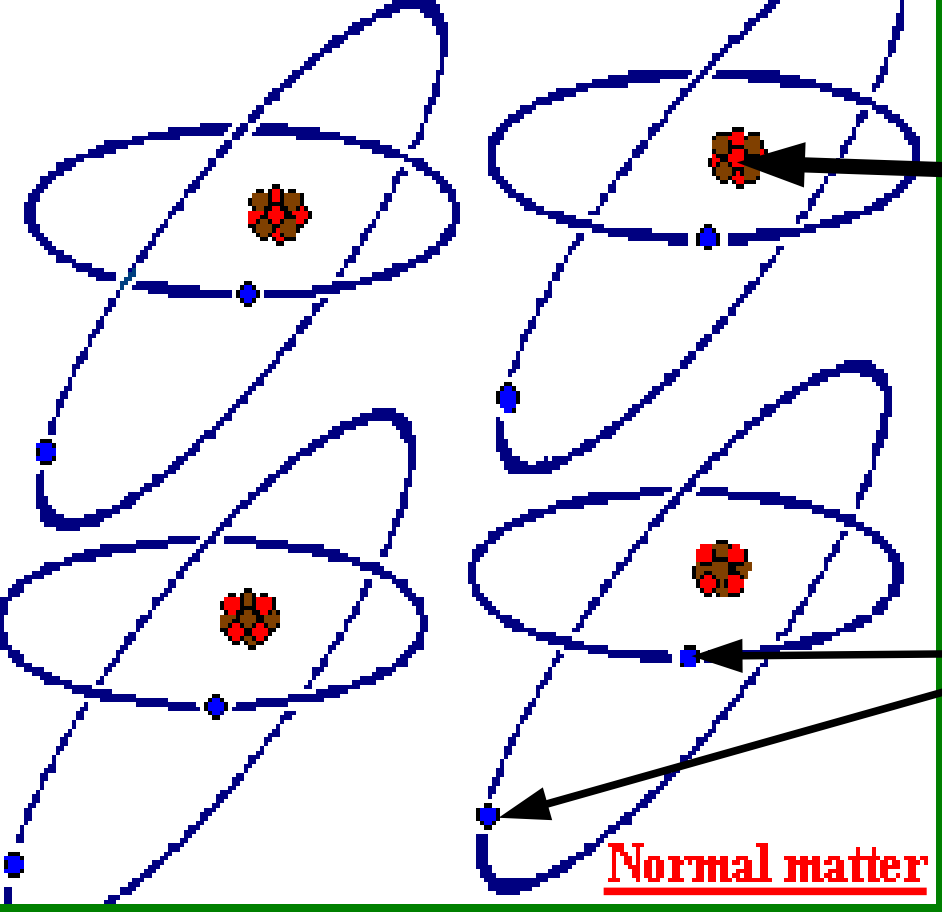
Buchi neri stellari (< 15 Masse solari)

Buchi neri intermedi (100, 1000 Masse solari) ?????

Come viene prodotto un buco nero ?

Equilibrio: qualcosa deve opporsi alla GRAVITA'



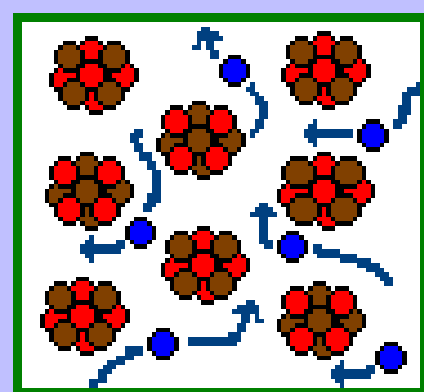
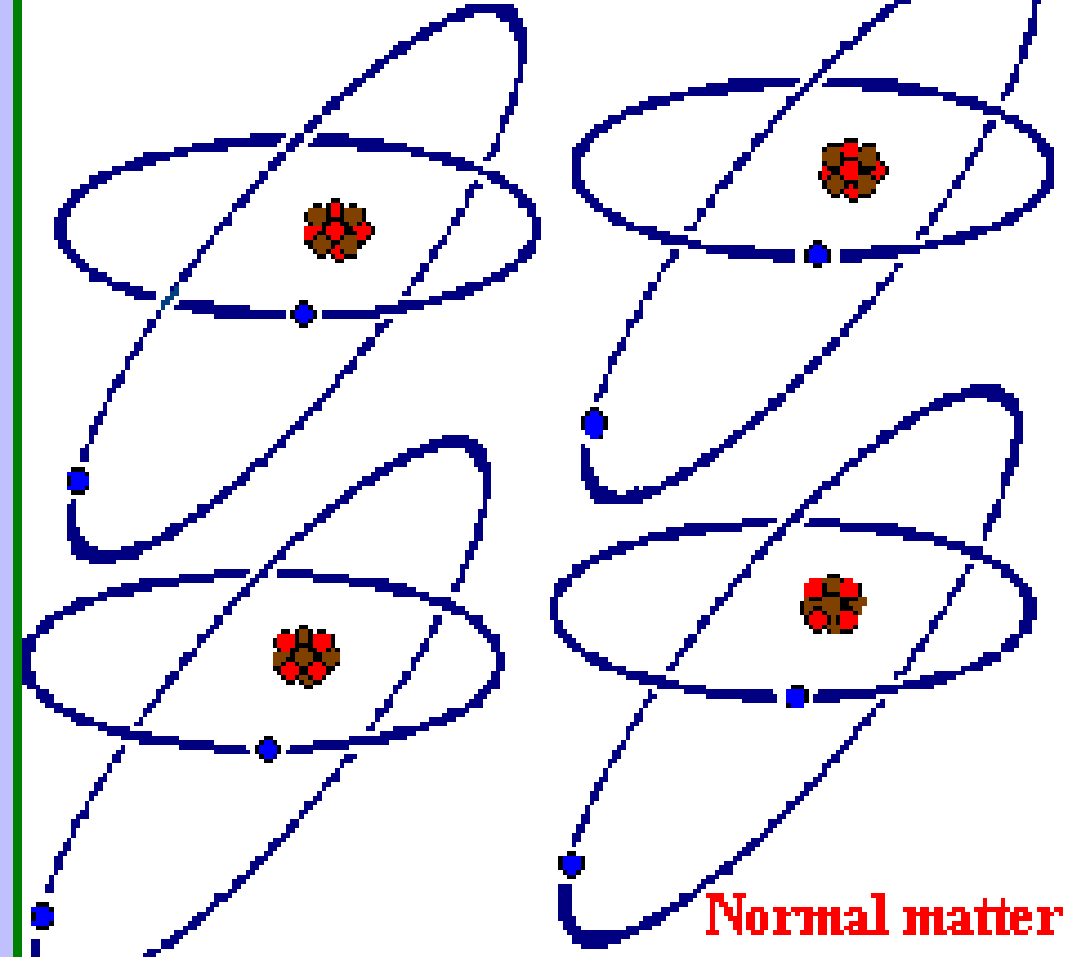


**La materia:
ATOMI
(Protoni+Neutroni, elettroni)**

Normal matter

Molto “spazio vuoto” nella materia normale

...Ma,
fino a che punto si può comprimere la materia?



Gravitational
Compression
1 tonne/cc
Electron degenerate
matter

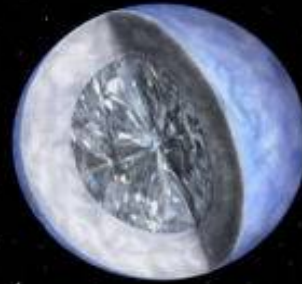


STOP del collasso

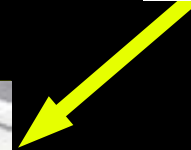
Equilibrio: Gravita' - Pressione elettronica (degenere)

Nana Bianca

La massa del sole...ma piccola come la Terra.



Densita': 1 Tonnellata /cm³



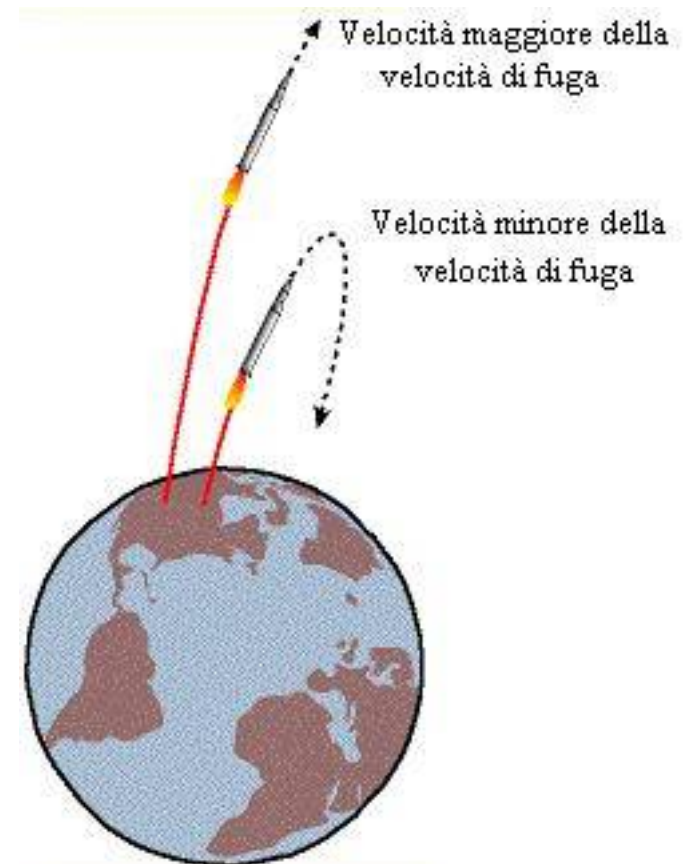
White
dwarf



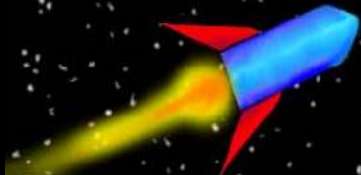
← Sun

Aumenta la velocita' di fuga

Velocita' di fuga



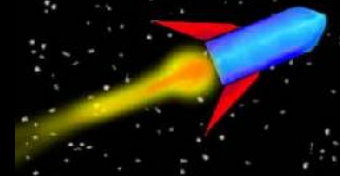
11 km/s



5.000 km/s

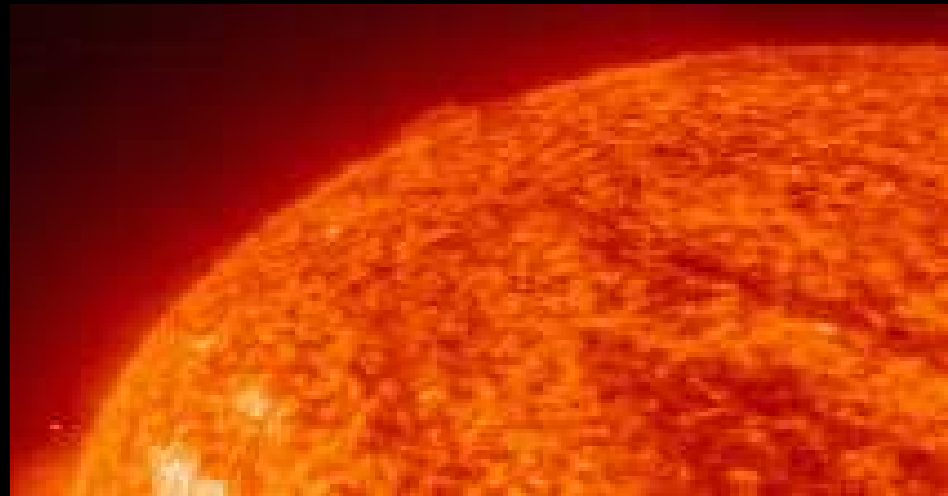


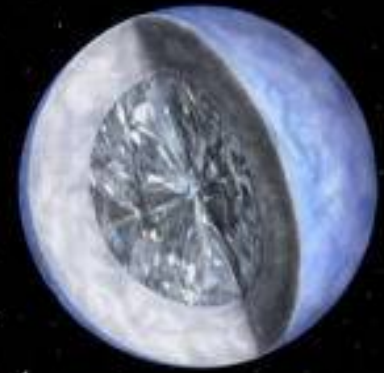
617 km/s



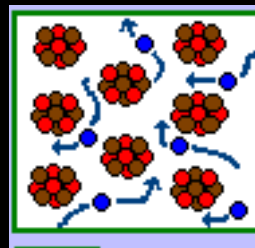
La velocita' di fuga

$$v = \sqrt{\frac{2GM}{R}}$$





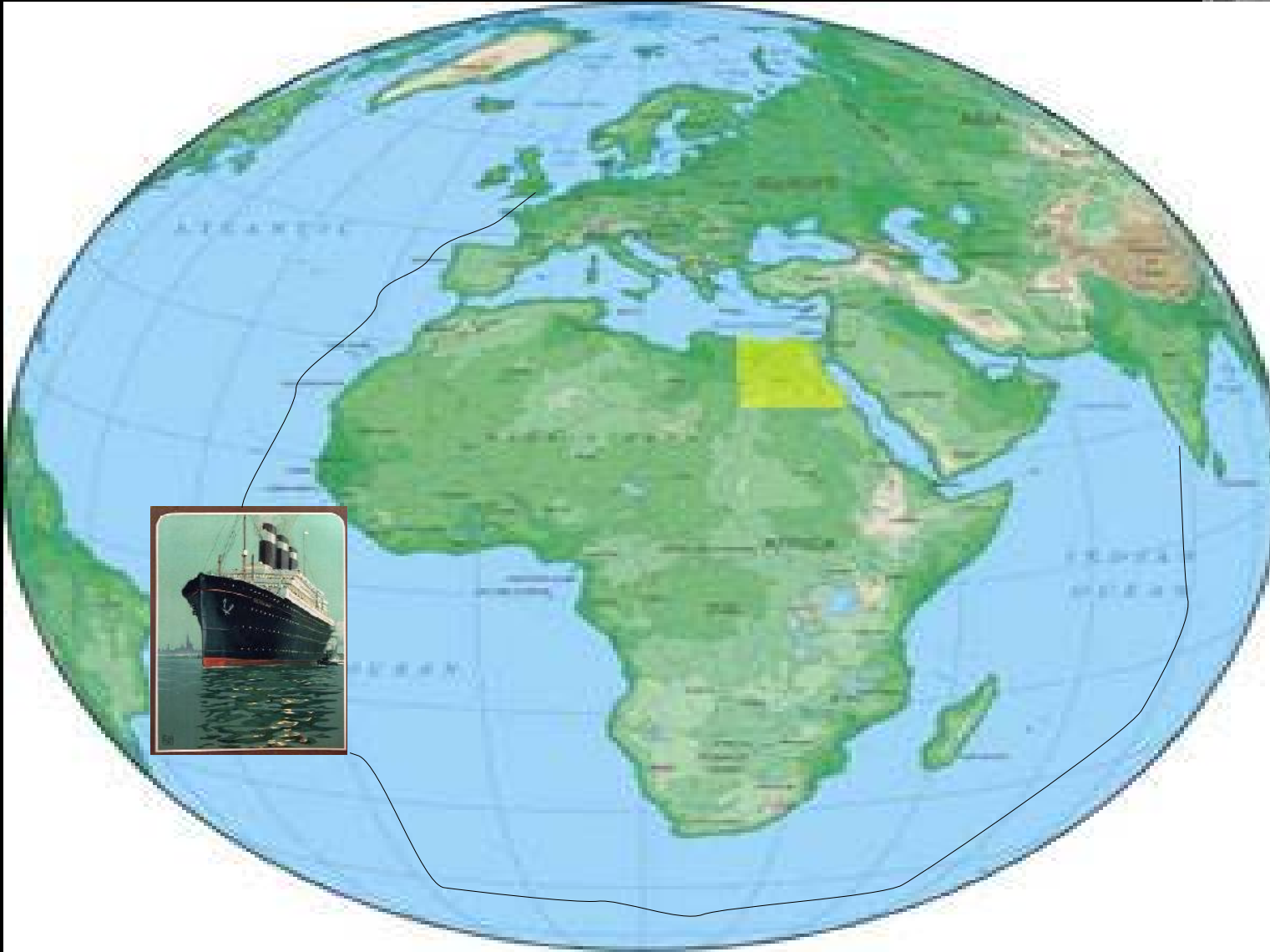
Cosa succede se ad una Nana Bianca aggiungo massa?



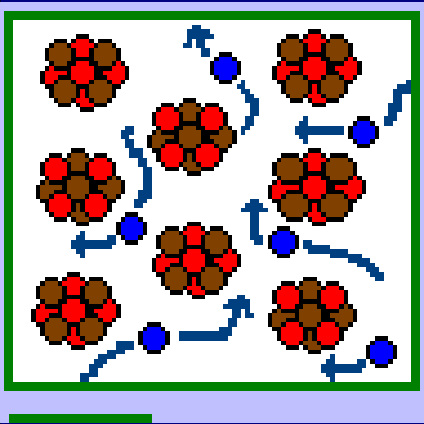
Chandrasekhar

Viaggio dall' India fino in Inghilterra (1930).

Limite: 1.4 Masse Solari



COLLASSO !



Elettroni e Protoni formano Neutroni

Nuovo Equilibrio: Gravita' - Pressione dei neutroni

STOP del collasso !



Neutron
star

Stella di Neutroni

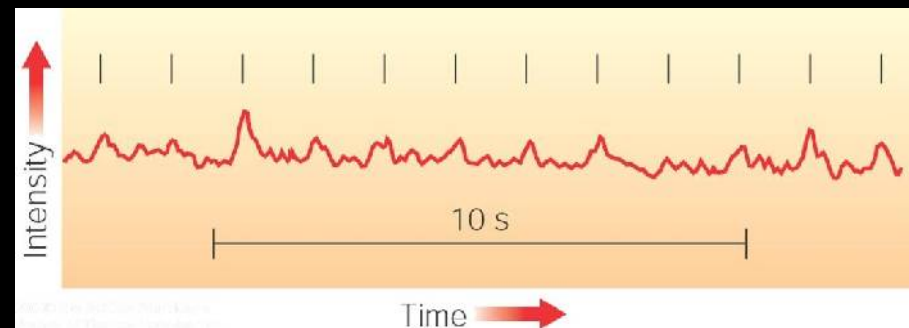
100 Mil. Tonnellate/cm³

PULSAR



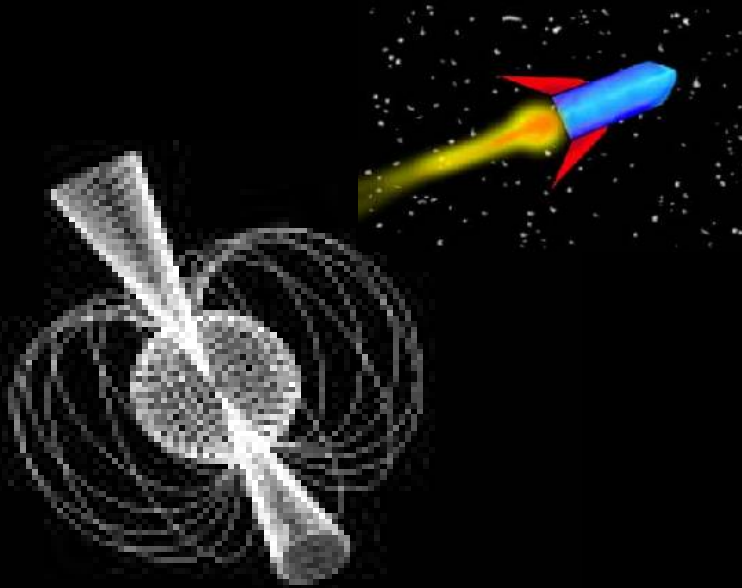
White
dwarf

← Sun



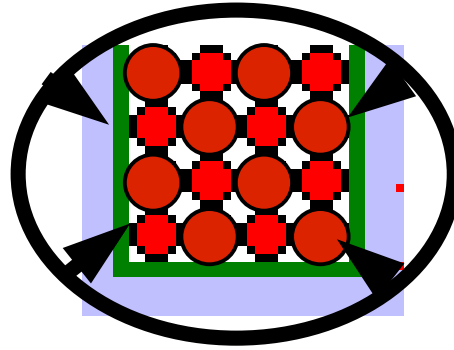
Velocita' di fuga

$$v = 250.000 \text{ km/s}$$



Velocita' massima possibile:

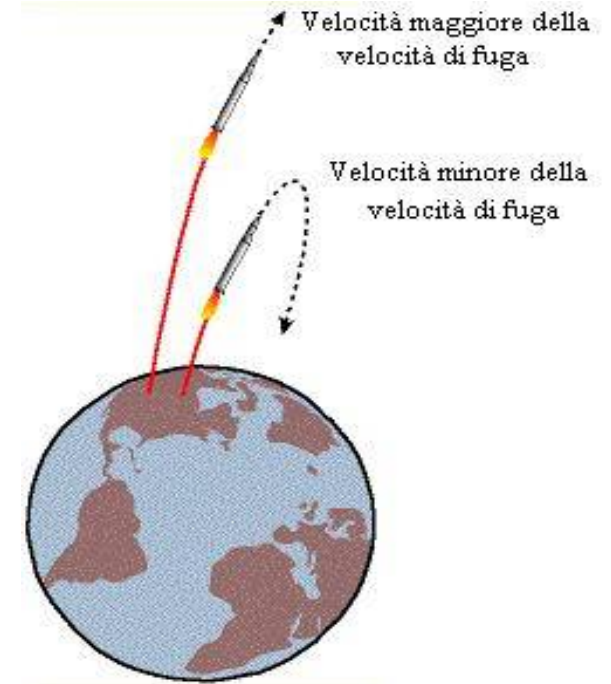
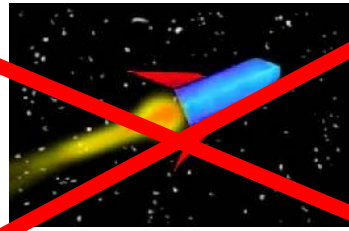
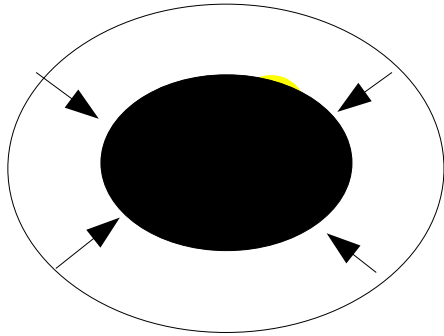
La velocita' della luce



Massa Limite Stella di Neutroni : 3 Masse Solari

La gravita' vince sulla pressione dovuta ai Neutroni

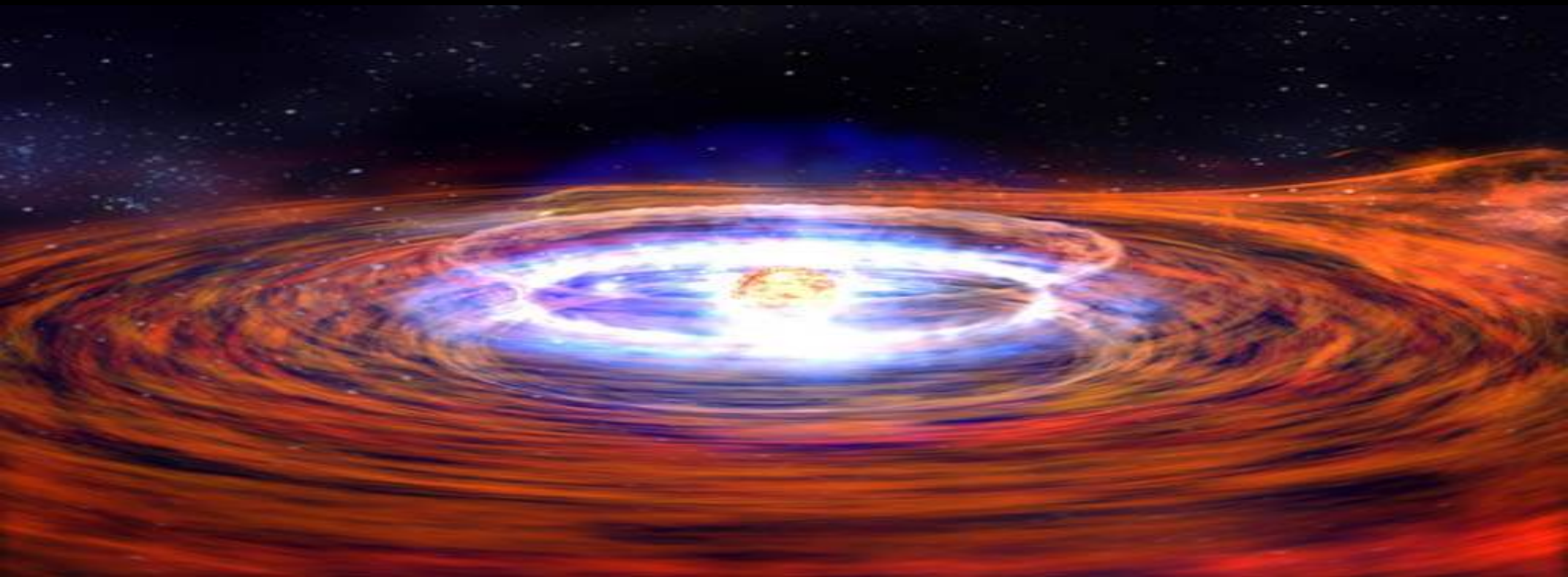
Velocita' di fuga = Velocita' della luce



Neanche la luce puo' abbandonare l'oggetto collassante:

BUCO NERO

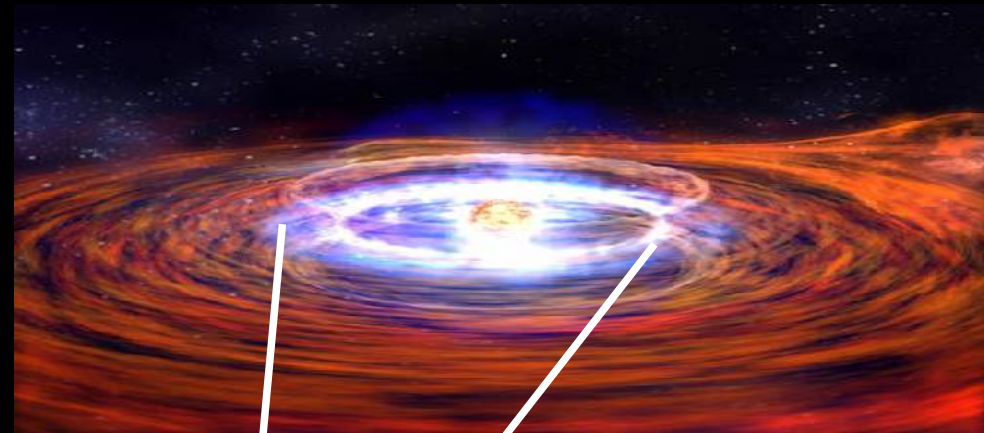
Il disco di accrescimento



$$M_{\text{BH}} \sim 10^9 M_{\text{Sole}}$$

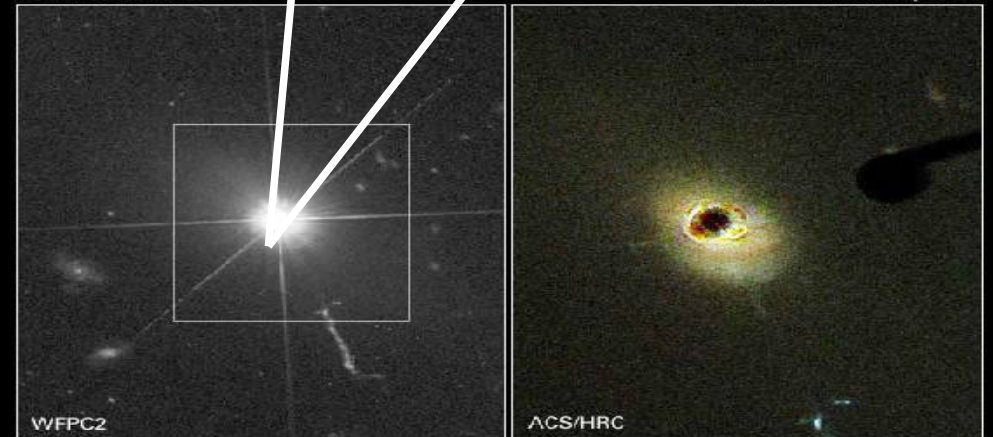
Quasar

$$L_{\text{Quasar}} \sim 100 L_{\text{Galassia}}$$



Quasar 3C 273

HST - WFPC2, ACS



Come sono stati generati i Quasar ?

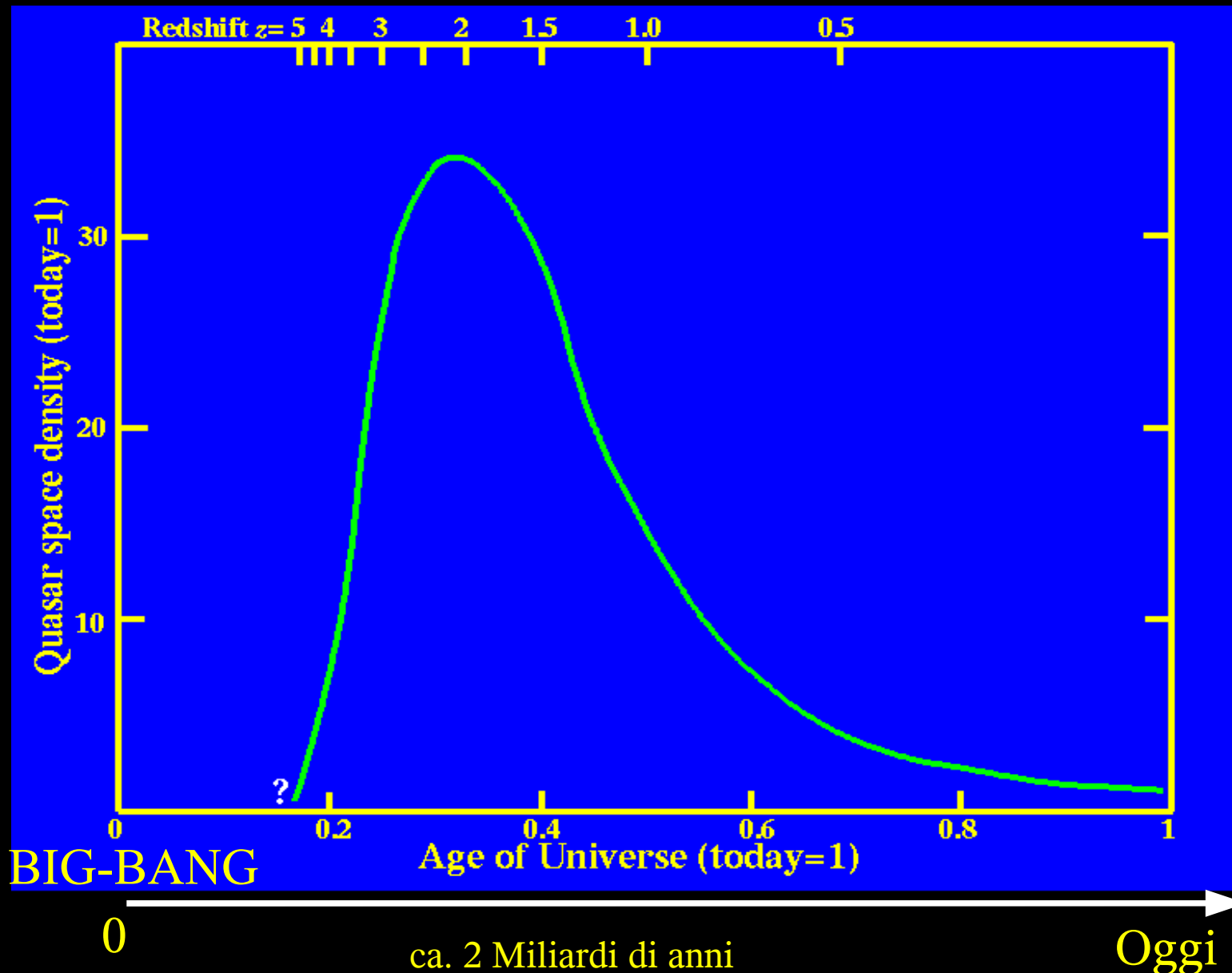
I Quasar vengono trovati soprattutto a grandi distanze

Andromeda
Distanza ~2.5 Milioni di anni luce



Distanza = Passato

Pochissimi i Quasar relativamente vicini a noi.
I piu' sono a grande distanza (ossia nel passato)



Perche' i Quasar sono stati generati soprattutto nel passato ?

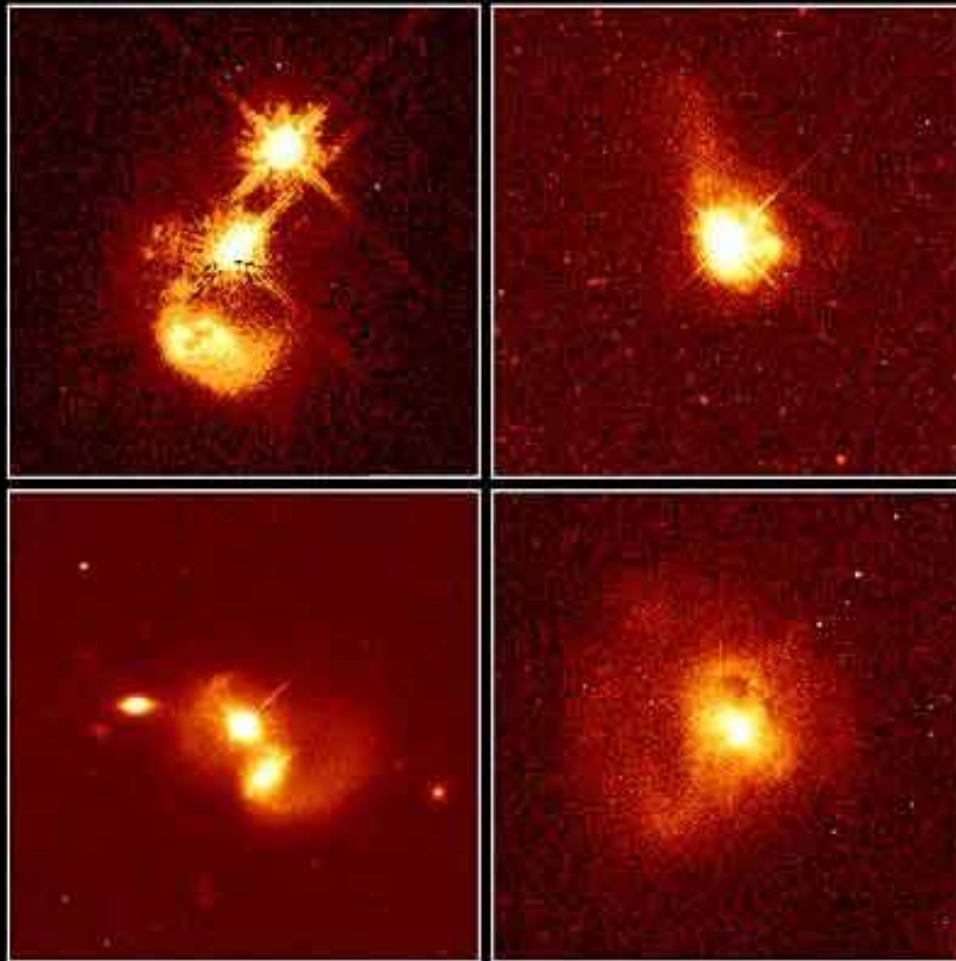
Quasar = Disco di accrescimento intorno ad un buco nero

Luminosita' di 100 galassie solo se
il buco nero “ingoia” 2 masse solari/anno

Quale meccanismo ha portato nel passato cosi' tanto gas al
centro delle galassie ?

Telescopio HUBBLE

Galassie in collisione !!!



Quasar Host Galaxies

HST • WFPC2

PRC96-35a • ST ScI OPO • November 19, 1996

J. Bahcall (Institute for Advanced Study), M. Disney (University of Wales) and NASA

The Model

Progenitors

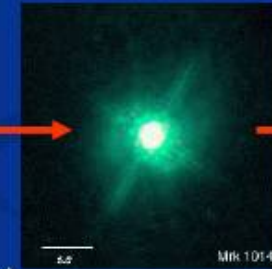


Merger phase

- Gas compression
- Star formation
- Black hole fueling/building



Quasar phase



Elliptical

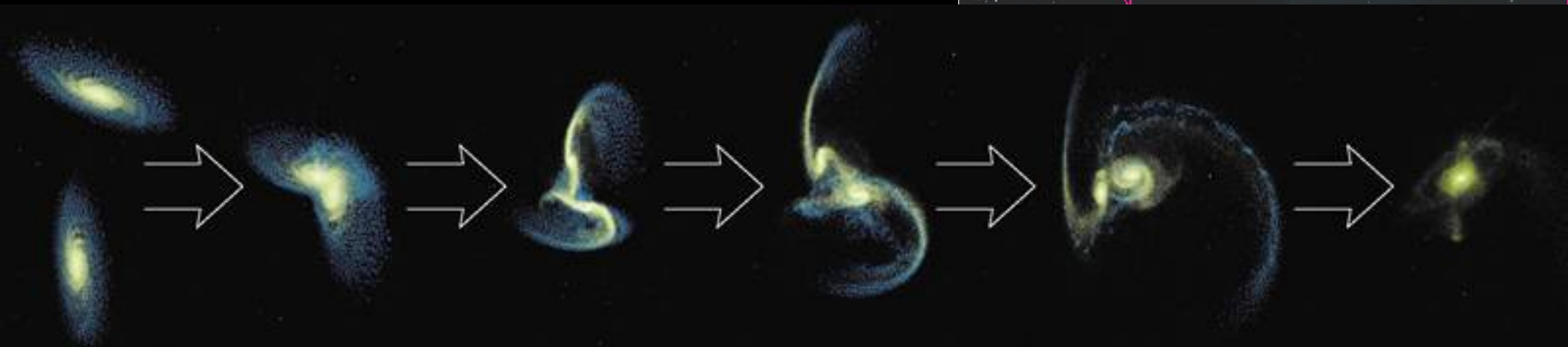


100 million years

1 billion years

Time





Two simulated spiral galaxies approach each other on a collision course.

The first encounter begins to disrupt the two galaxies and sends them into orbit around each other.

As the collision continues, much of the gas in the disk of each galaxy collapses toward the center.

Gravitational forces between the two galaxies tear out long streamers of stars called tidal tails.

The centers of the two galaxies approach each other and begin to merge.

The single galaxy resulting from the collision and merger is an elliptical galaxy surrounded by debris.



Collisione tra galassie a 300 Milioni di anni luce

Perche' tali collisioni erano nel passato piu' frequenti ?

IMAGE: NASA/HUBBLE/STScI/H. Ford et al.

Time since the
Big Bang (years)

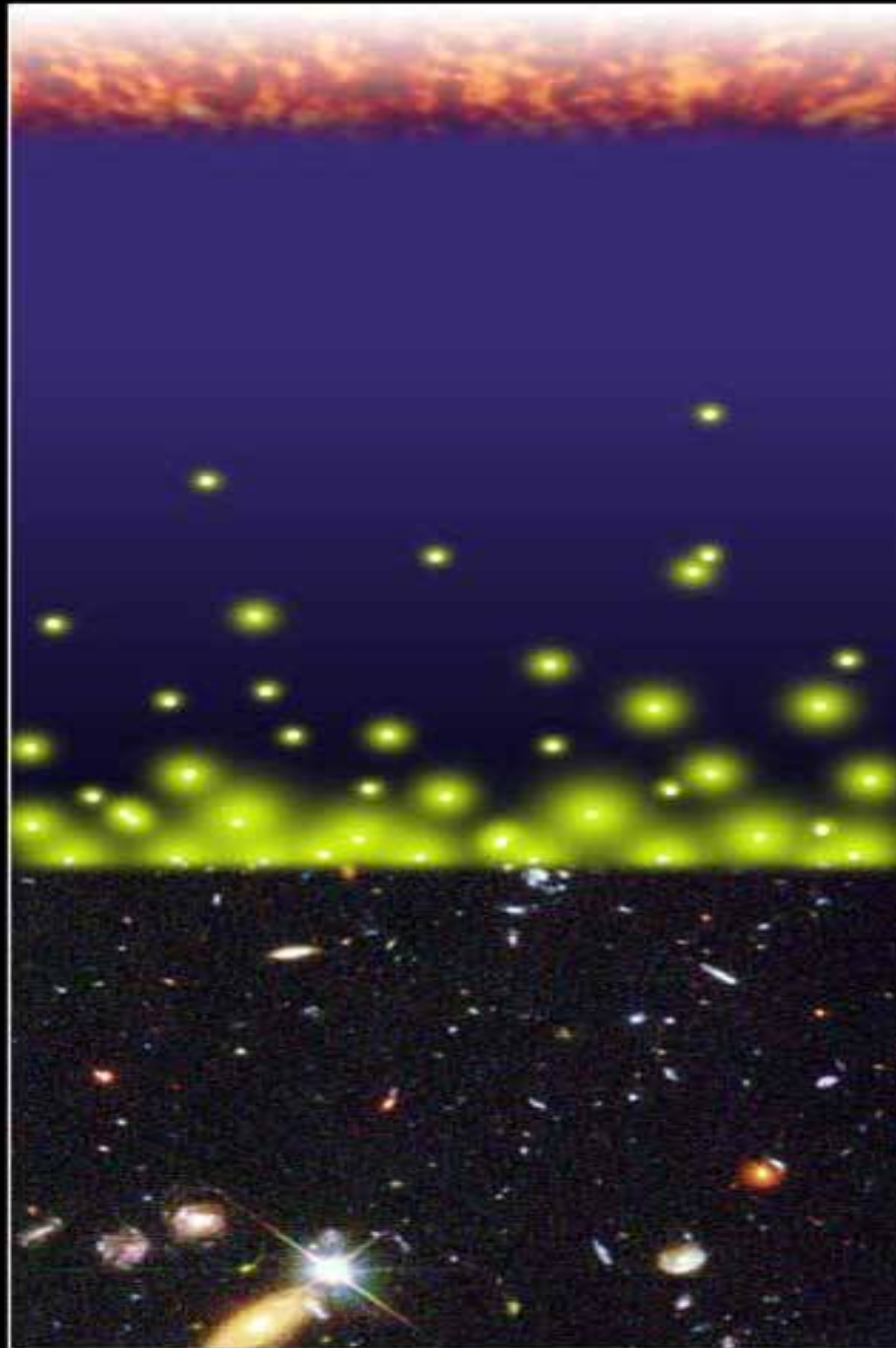
~ 300 thousand

~ 500 million

~ 1 billion

~ 9 billion

~ 13 billion



← The Big Bang

The Universe filled
with ionized gas

← The Universe becomes
neutral and opaque

The Dark Ages start

Galaxies and Quasars
begin to form
The Reionization starts

The Cosmic Renaissance
The Dark Ages end

← Reionization complete,
the Universe becomes
transparent again

Galaxies evolve

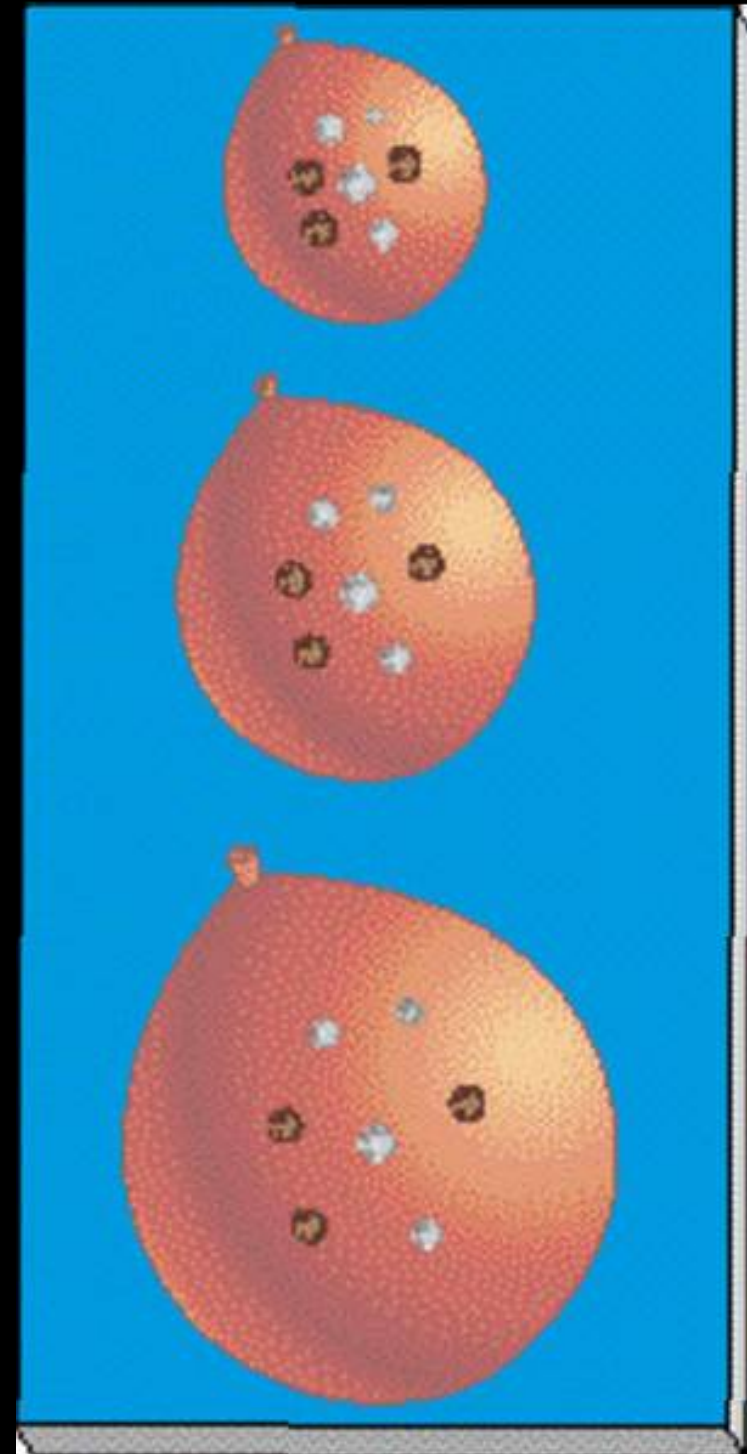
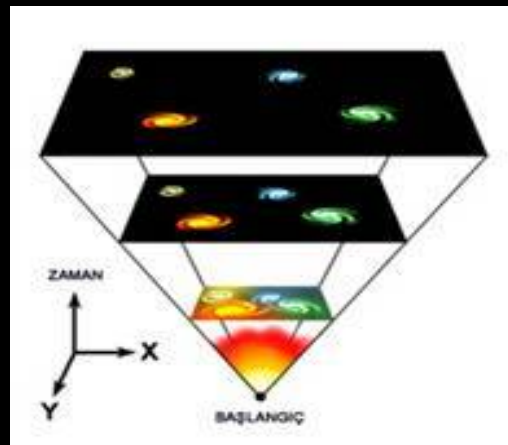
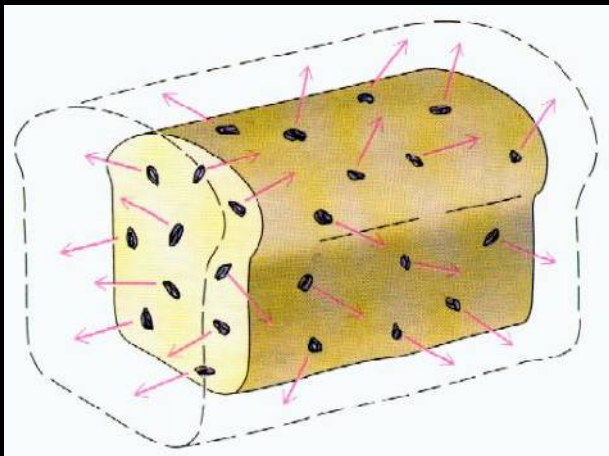
The Solar System forms

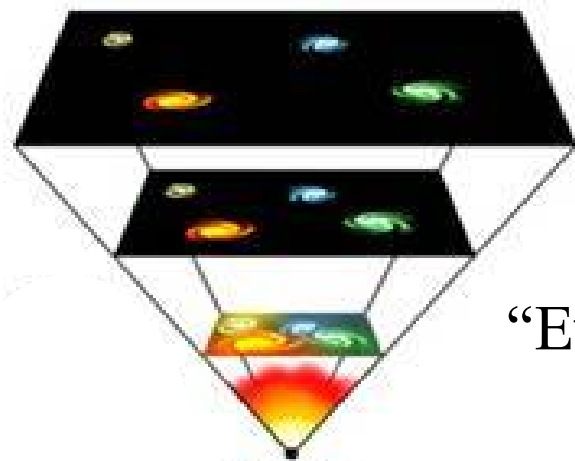
Today: Astronomers
figure it all out!

Big Bang: circa 14 miliardi di anni fa

Formazione Galassie: dopo circa un miliardo di anni.

In un universo in espansione le distanze tra le galassie aumentano





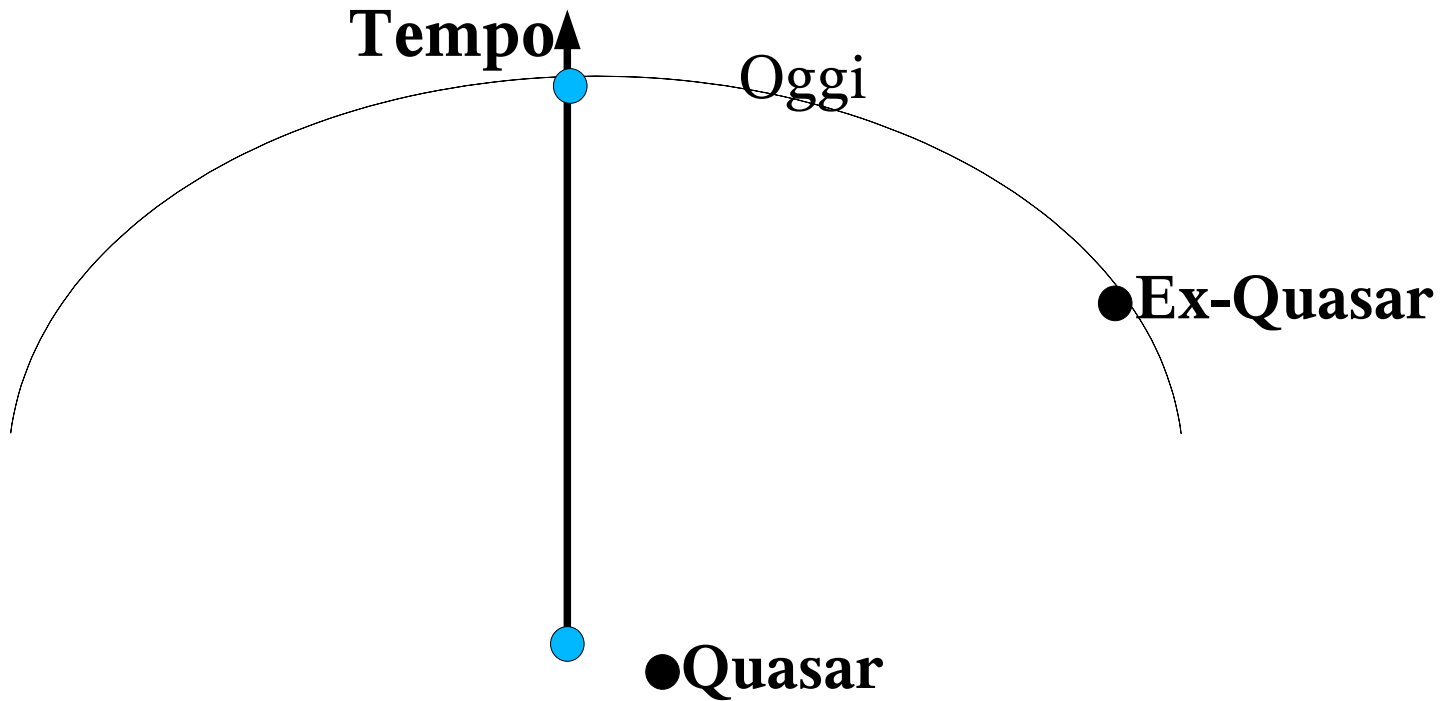
Universo Locale

“Eta' d'oro” dei Quasar

Universo piu' piccolo = Galassie piu' vicine

Big-Bang

Un Quasar puo' vivere al massimo 100 Milioni di anni

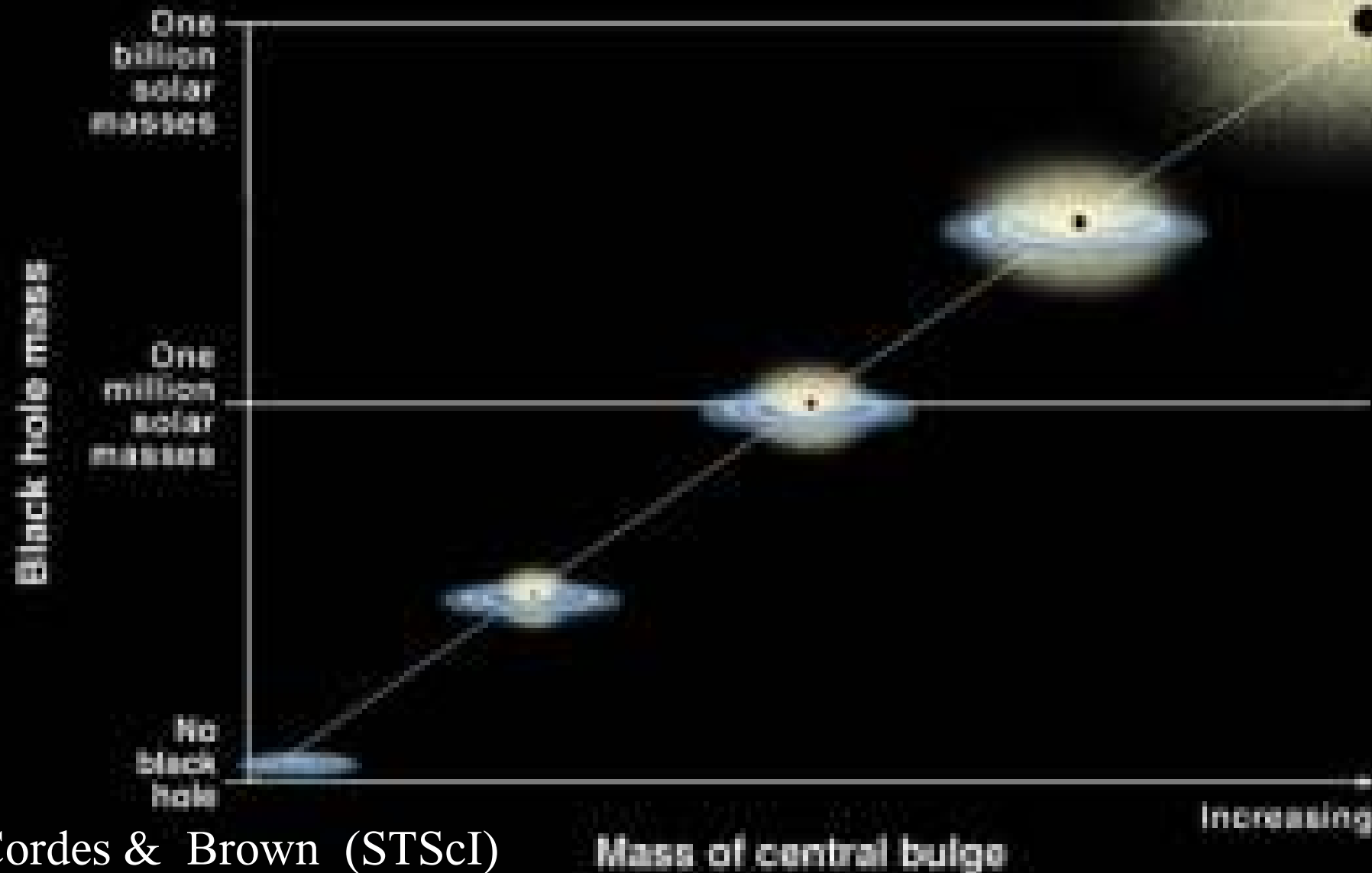


Quando non c'e' piu' gas da “ingoiare” finisce la fase quasar.

Resta il buco nero.

Correlation Between Black Hole Mass and Bulge Mass

Cordes & Brown (STScI)

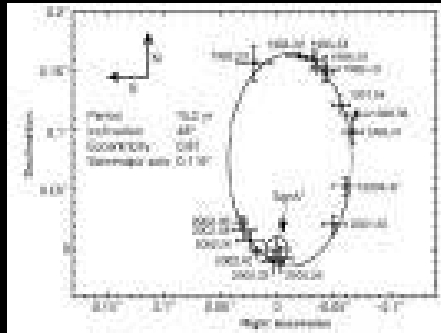
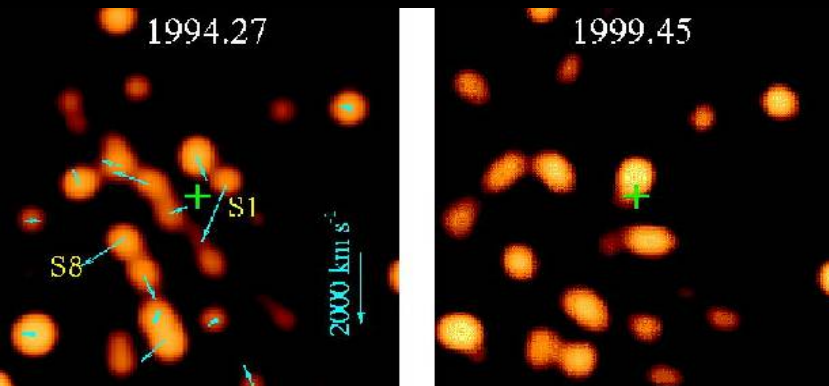


Cordes & Brown (STScI)

<http://spaceflightnow.com/news/n0006/05hstblackholes/>

Osservazioni dal 1992 al 2002 delle stelle nel centro della nostra galassia rivelano:

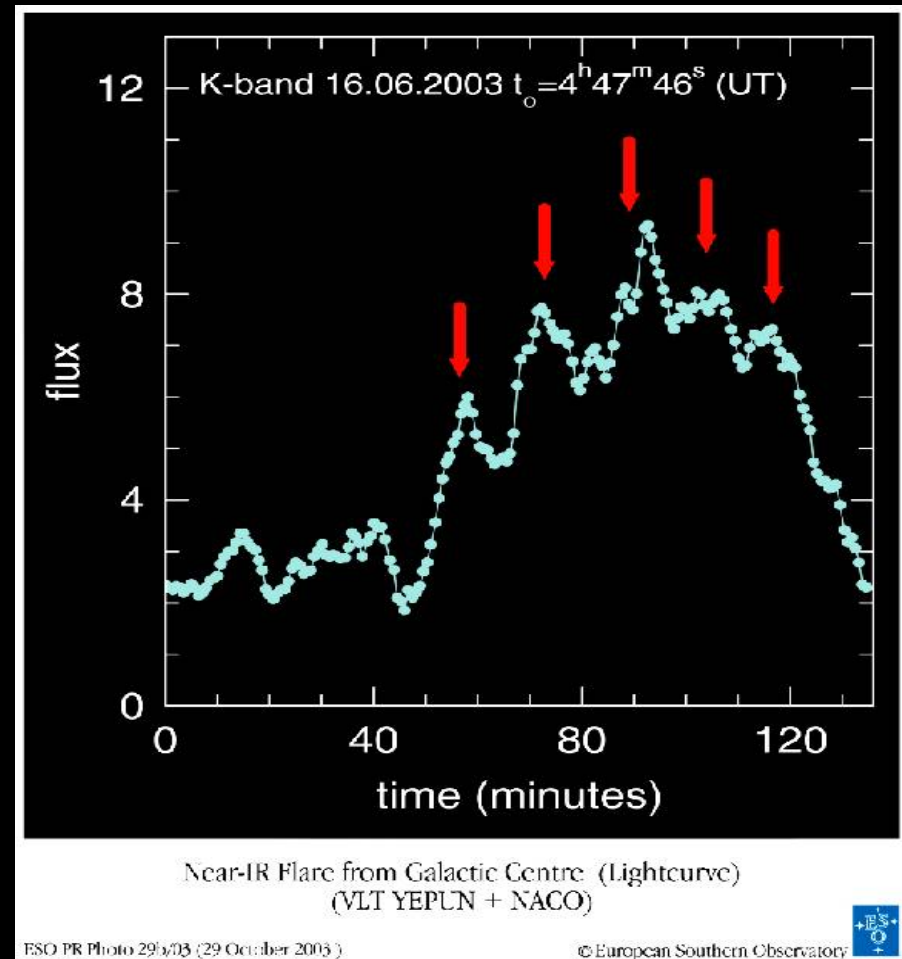
Un buco nero di circa 3,6 Milioni di masse solari



Schödel et al. 2002

Nuove osservazioni nel 2003

Lampi ogni 17 minuti



Genzel et al. 2003

SOMMARIO

Cosa e' un Quasar ?

Il disco di accrescimento di un buco nero supermassiccio

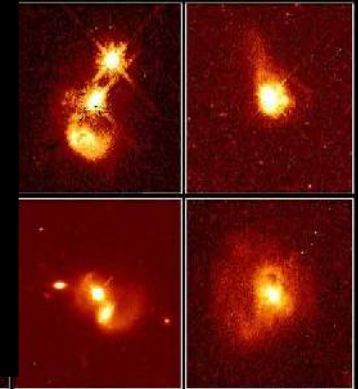


Come sono stati generati i Quasar ?

Collisione tra galassie.

Cosa resta dopo la fase Quasar ?

Un buco nero “dormiente”



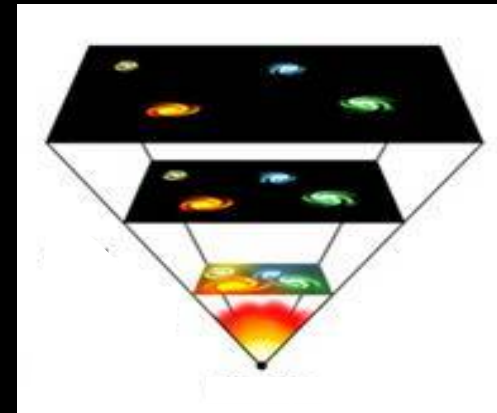
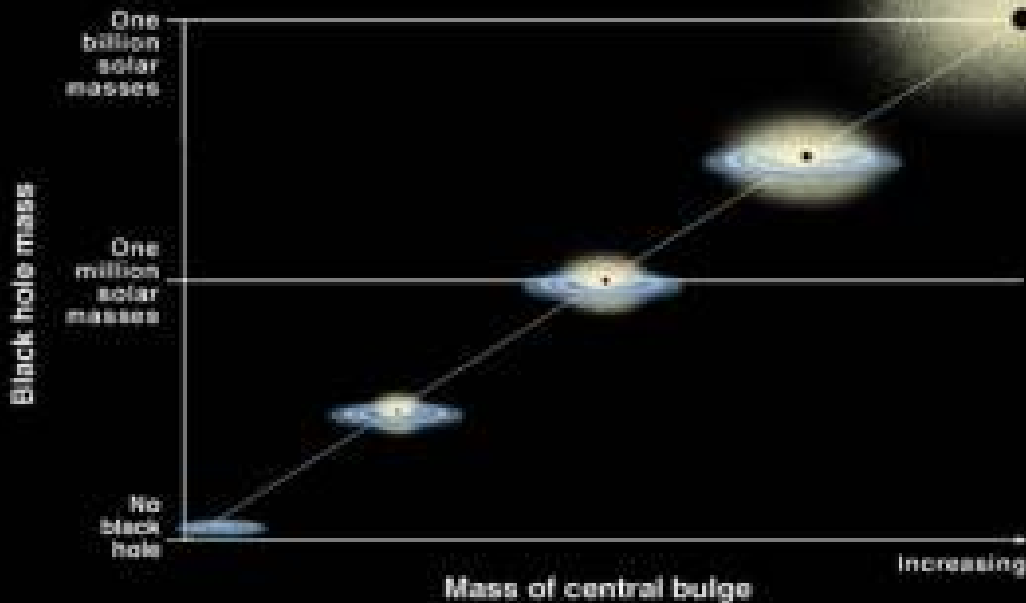
Quasar Host Galaxies

PRC96-35a • ST ScI CPO • November 19, 1996

J. Bahcall (Institute for Advanced Study), M. Disney (University of Wales) and NASA

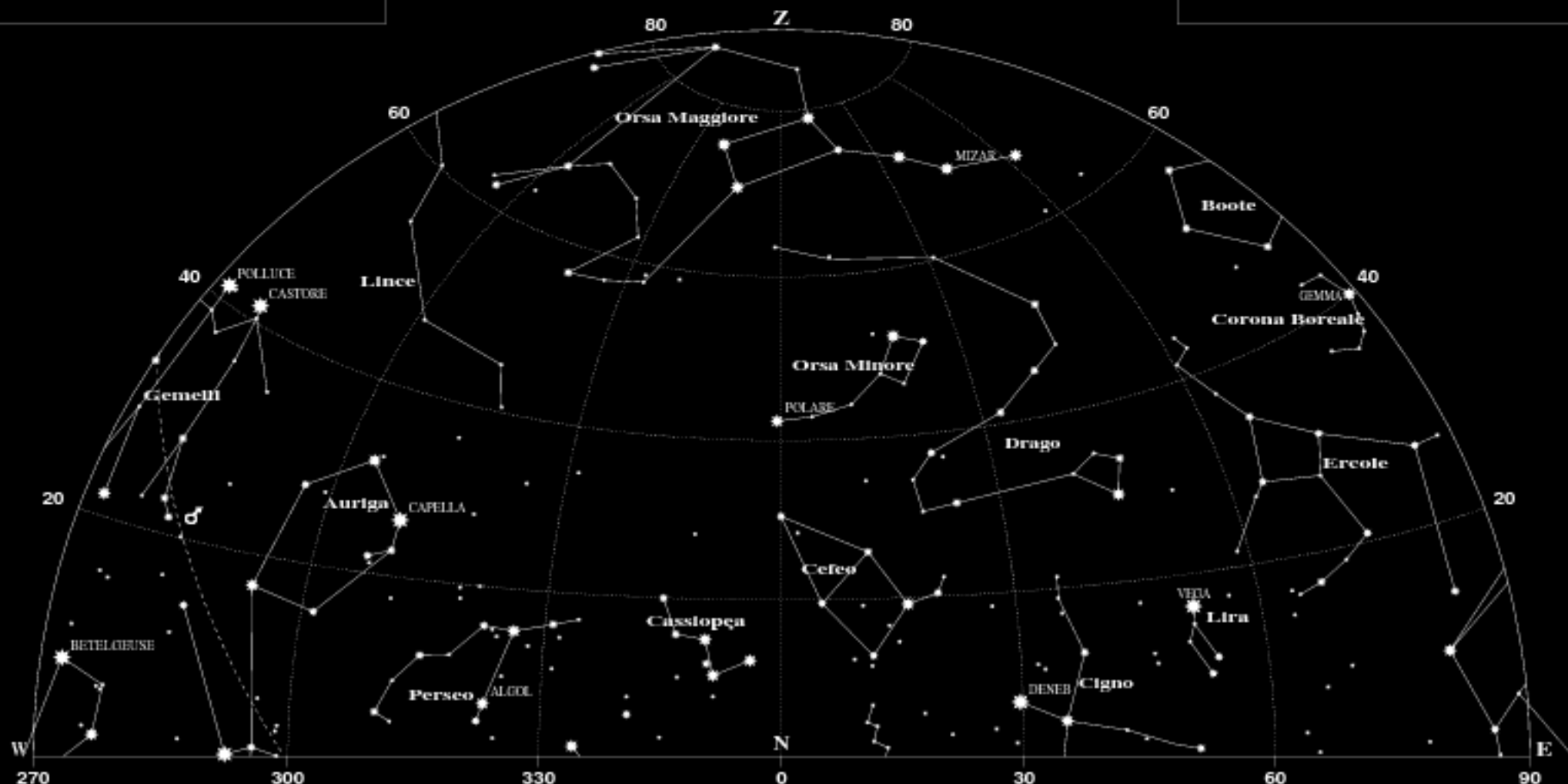
HST • WFPC2

Correlation Between Black Hole Mass and Bulge Mass



FINE





R. Andreani - G. Forti 1996

- ★ - fino a 1.5 magnitudini
- - da 1.6 a 2.5 magnitudini
- - da 2.6 a 3.5 magnitudini
- - da 3.6 a 4.5 magnitudini

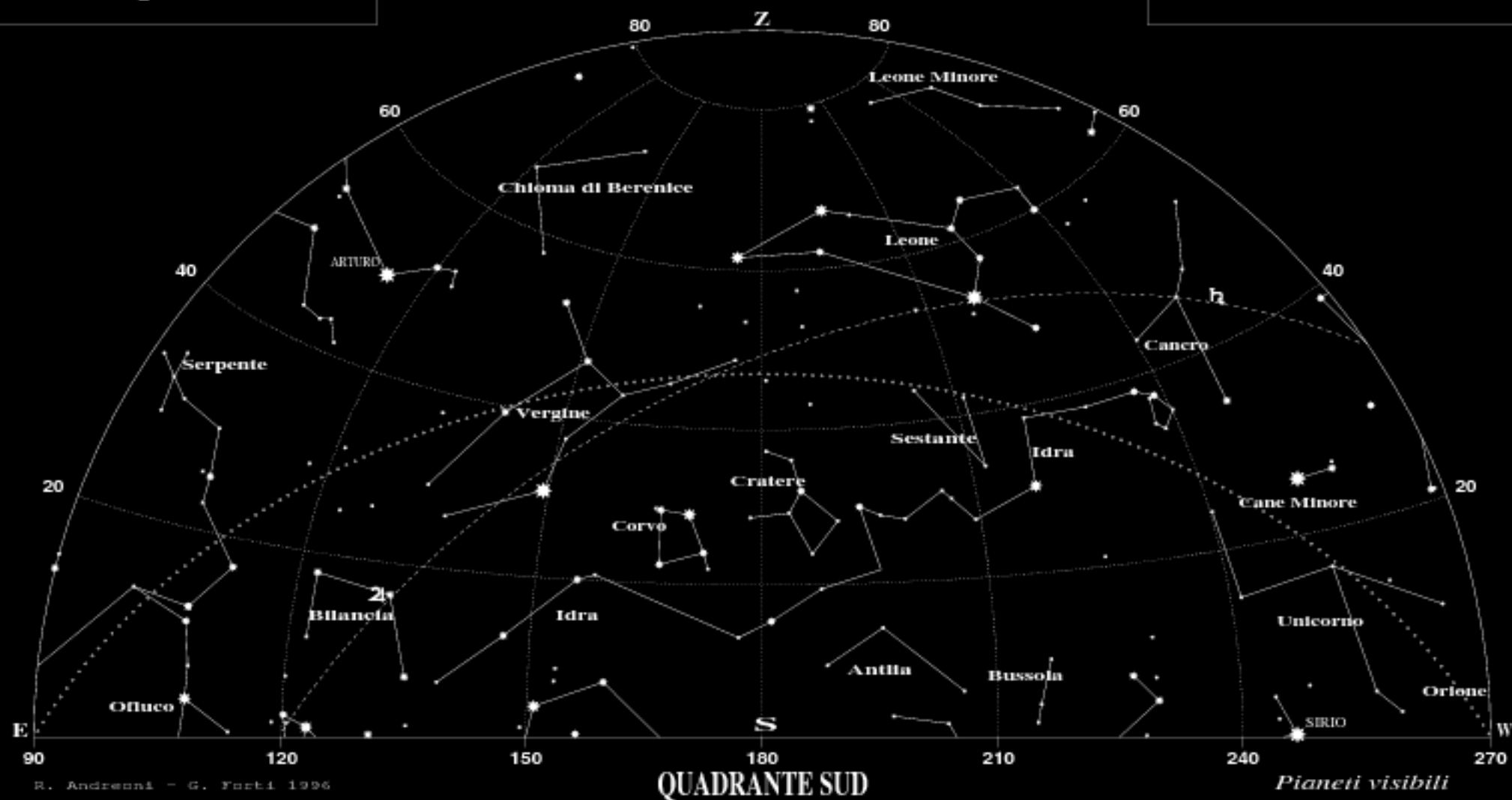
QUADRANTE NORD

----- ECLITTICA

Pianeti visibili
♂ MARTE

VISTA ALTO-AZIMUTALE DEL CIELO PER IL GIORNO 17-04-2006

TEMPO CIVILE 22^h00'00"
LATTITUDINE 42°55'00"
LONGITUDINE E. 0°55'12"



R. Andreani - G. Forti 1996

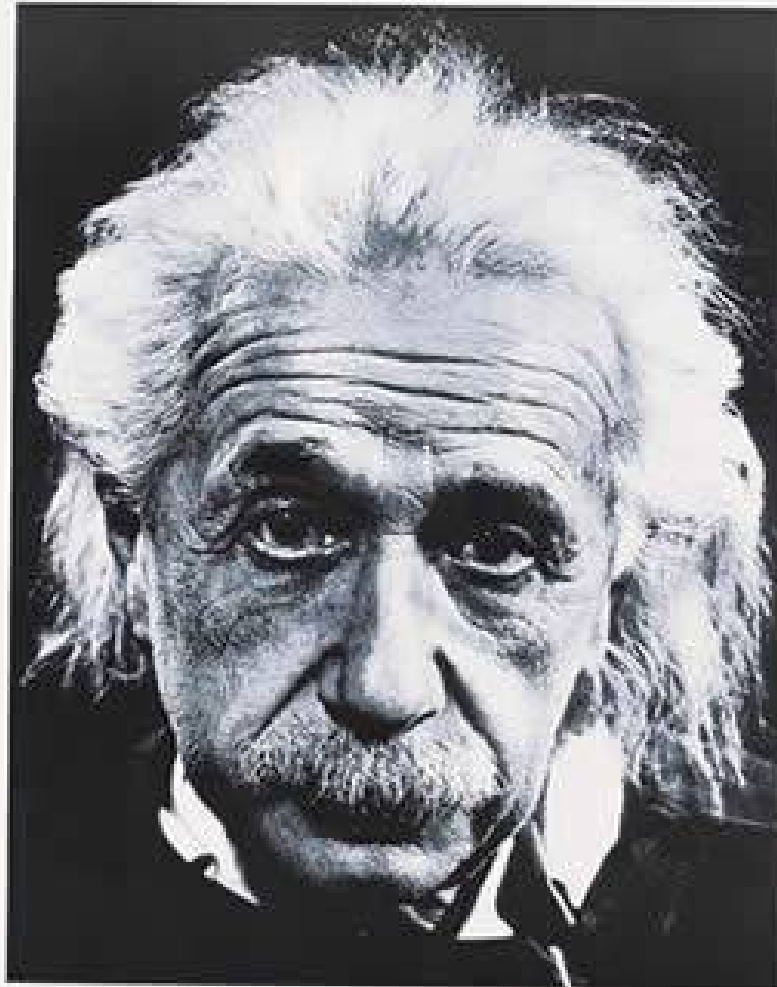
- ★ - fino a 1.5 magnitudini
- - da 1.6 a 2.5 magnitudini
- - da 2.6 a 3.5 magnitudini
- - da 3.6 a 4.5 magnitudini

----- ECLITTICA
..... EQUATORE CELESTE

Pianeti visibili

- ♃ GIOVE
- ♄ SATURNO

*"I want to know
God's thoughts..."*



*...the rest are details."
Einstein*