

La luce invisibile delle stelle

Come mettere alla prova Einstein con la
radioastronomia



Marta Burgay

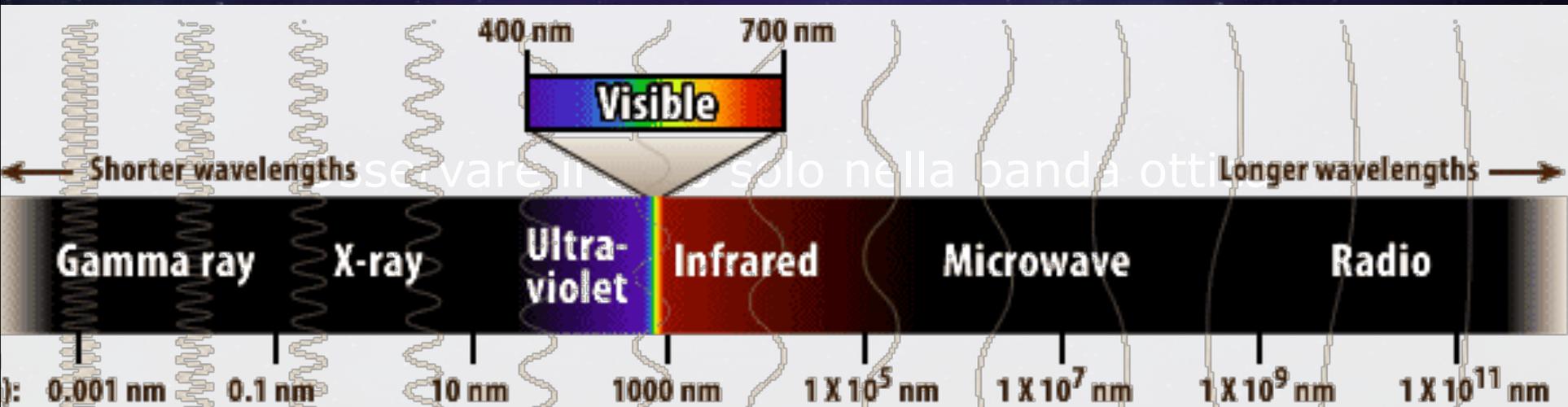
INAF – Osservatorio Astronomico di Cagliari



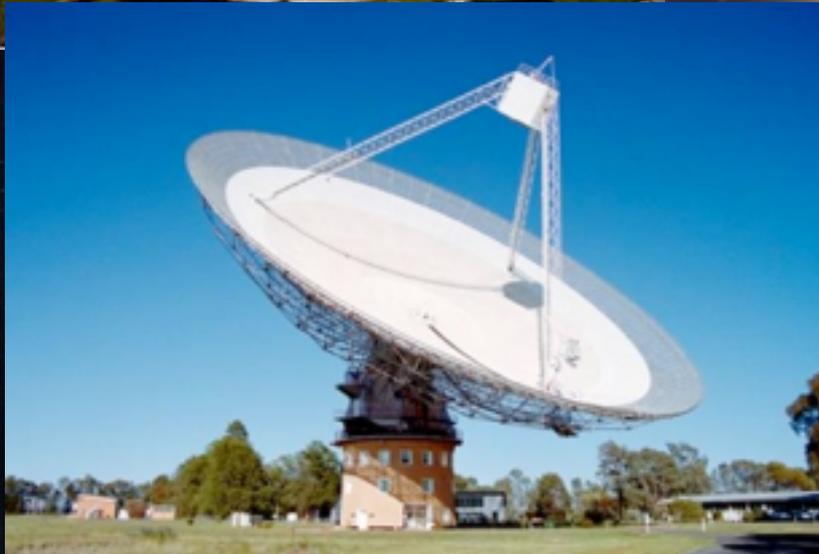




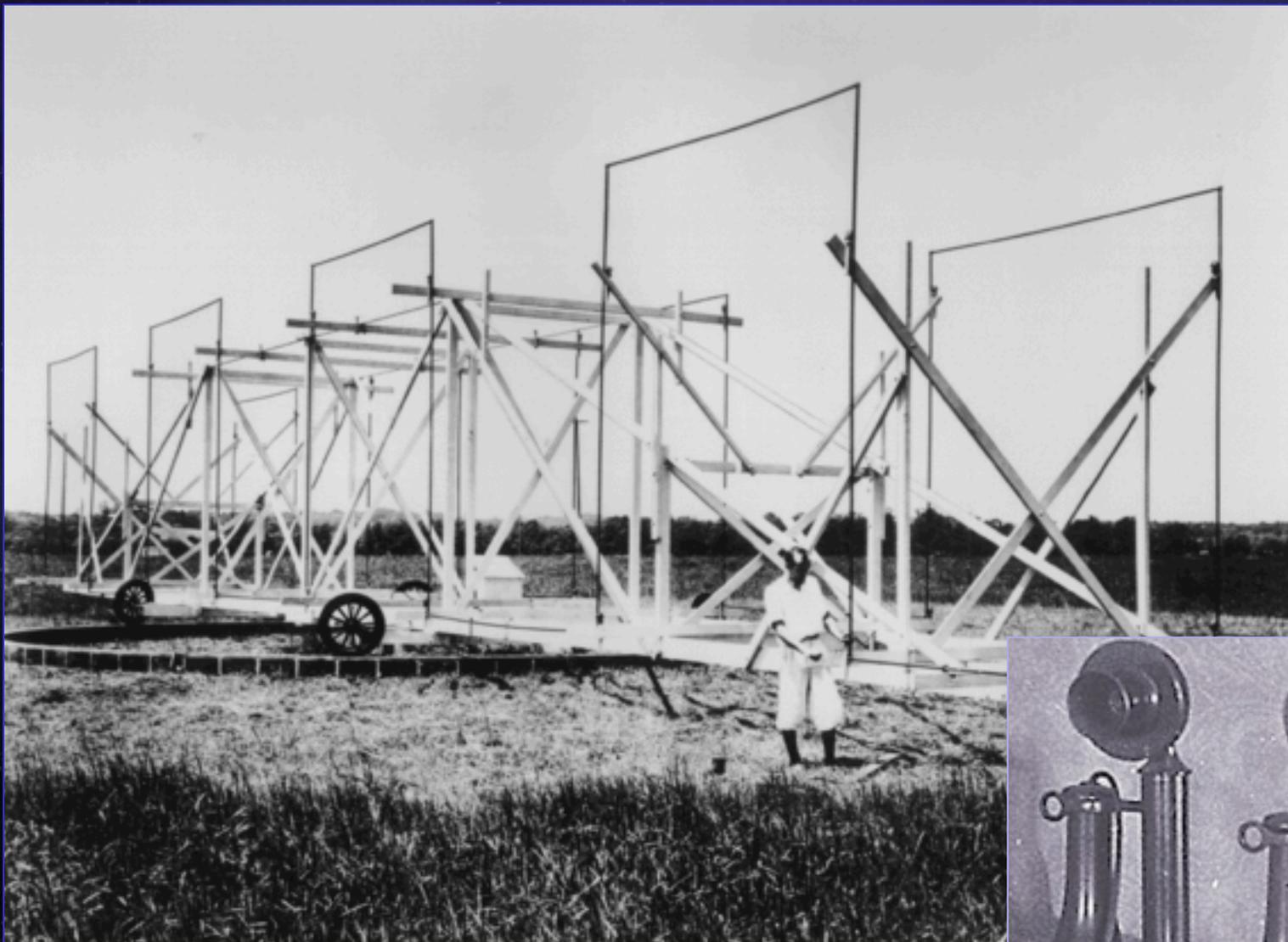
Lo spettro elettromagnetico



L'Astronomia multi-frequenza



La Radioastronomia



1932: Karl Jansky

Sorgente dell'emissione radio era una regione di cielo nella regione del Sagittario, prossima al centro della nostra galassia

L'annuncio della notizia è uno scoop giornalistico mondiale; il New York Times del 5 maggio 1933 titola:



Radio onde dal Centro della Via Lattea!

5 maggio 1933

"All the News That's Fit to Print"

The New York Times

LATE-CITY EDITION

NEW RADIO WAVES TRACED TO CENTRE OF THE MILKY WAY

Washington, May 4.—(Special to N. Y. Times.)—A new discovery in the field of radio astronomy has been made by the National Radio Astronomy Observatory at Green Bank, West Virginia.

The discovery was made by Dr. Grote Reber, who has been working for several years on the problem of tracing the source of the radio waves which are received on earth from outer space.

Dr. Reber has now succeeded in tracing these waves to the center of the Milky Way galaxy, a distance of about 25,000 light years from earth.

The discovery is of great importance because it shows that the radio waves are not merely reflected from the surface of the earth, but are actually coming from a distant source.

Dr. Reber's discovery is the first step toward a better understanding of the structure of the universe.

Pluto Was in Cook's Spectral Studies

Washington, May 4.—(Special to N. Y. Times.)—The discovery that the planet Pluto was in Cook's spectral studies was announced today by the National Radio Astronomy Observatory at Green Bank, West Virginia.

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BIG NEW INVASION PLANNED BY JAPAN ON ROAD TO PEKING

London, May 4.—(Special to N. Y. Times.)—A large-scale offensive that has been planned in Japan is announced in a dispatch from Peking.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the Japanese forces.

The Japanese government has announced that it is preparing to launch a large-scale offensive against the Chinese forces in the region of Peking.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the Japanese forces.

Large Bonus for Miller As Prop to Refuse Vote

Washington, May 4.—(Special to N. Y. Times.)—A large bonus for Miller is proposed in a bill introduced in the House of Representatives.

The bill is expected to pass and will result in a major victory for the Miller forces.

The Miller forces have announced that they are preparing to launch a large-scale offensive against the opposition forces.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the Miller forces.

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

RAIL PROGRAM WIDENED

Washington, May 4.—(Special to N. Y. Times.)—The President today announced that he has signed a bill which widens the scope of the railroad program.

The bill is expected to pass and will result in a major victory for the railroad forces.

The railroad forces have announced that they are preparing to launch a large-scale offensive against the opposition forces.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the railroad forces.

Features of Railroad Bill

Washington, May 4.—(Special to N. Y. Times.)—The features of the railroad bill are as follows:

- 1. The bill provides for a 10 percent increase in the wages of railroad workers.
- 2. The bill provides for a 10 percent increase in the wages of railroad employees.
- 3. The bill provides for a 10 percent increase in the wages of railroad clerks.
- 4. The bill provides for a 10 percent increase in the wages of railroad conductors.
- 5. The bill provides for a 10 percent increase in the wages of railroad engineers.

PRESIDENT TELLS IF GANG

Washington, May 4.—(Special to N. Y. Times.)—The President today told the members of the Chamber of Commerce that he is prepared to cooperate on three points.

The three points are:

- 1. The President is prepared to cooperate on the issue of the National Unity League.
- 2. The President is prepared to cooperate on the issue of the National Industrial Conference Board.
- 3. The President is prepared to cooperate on the issue of the National Labor Relations Board.

RECAPTURE RAPID MADE RETROACTIVE UNDER A FAR-REACHING PLAN

Washington, May 4.—(Special to N. Y. Times.)—A far-reaching plan for the retroactive application of the recapture law is announced today.

The plan is expected to pass and will result in a major victory for the recapture forces.

The recapture forces have announced that they are preparing to launch a large-scale offensive against the opposition forces.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the recapture forces.

KIDNAPPERS USED TO ANSWER PLEAS

Washington, May 4.—(Special to N. Y. Times.)—Kidnappers are used to answer the pleas of the accused in a new case.

The case is expected to pass and will result in a major victory for the kidnappers.

The kidnappers have announced that they are preparing to launch a large-scale offensive against the opposition forces.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the kidnappers.

CHINA PLACES AN ARMY

Washington, May 4.—(Special to N. Y. Times.)—China has placed an army in the region of Peking.

The army is expected to pass and will result in a major victory for the Chinese forces.

The Chinese forces have announced that they are preparing to launch a large-scale offensive against the opposition forces.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the Chinese forces.

FARM BILL CLAUSE BLOCKS AGREEMENT

Washington, May 4.—(Special to N. Y. Times.)—A clause in the farm bill blocks an agreement between the government and the farmers.

The clause is expected to pass and will result in a major victory for the government.

The government has announced that they are preparing to launch a large-scale offensive against the farmers.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the government.

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FRIENDS READY AS HOSTAGE

Washington, May 4.—(Special to N. Y. Times.)—Friends are ready as a hostage in a new case.

The case is expected to pass and will result in a major victory for the friends.

The friends have announced that they are preparing to launch a large-scale offensive against the opposition forces.

The offensive is planned to be launched in the near future and is expected to result in a major victory for the friends.

WAVE EAST AT DETROIT AND IN

Washington, May 4.—(Special to N. Y. Times.)—A wave of support is expected at Detroit and in other parts of the country.

The wave is expected to pass and will result in a major victory for the support forces.

The support forces have announced that they are preparing to launch a large-scale offensive against the opposition forces.

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BRITISH DEMANDING ITALIANS NOW BACK TARIFF SAFEGUARDS BRITISH ARMS PLAN

Washington, May 4.—(Special to N. Y. Times.)—The British government today demanded that Italy back its tariff safeguards and arms plan.

The British government has announced that it is preparing to launch a large-scale offensive against Italy.

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12 febbraio 2016

"All the News
That's Fit to Print"

The New York Times

Late Edition

Today, some sunshine giving way to times of clouds, cold, high 24. Tonight, a flurry or heavier squall late, low 23. Tomorrow, windy, high 14, low 11. Weather map, Page A18

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\$2.50

Clinton Paints Sanders Plans As Unrealistic

New Lines of Attack at Milwaukee Debate

By AMY CHOZICK
and PATRICK HEALY

MILWAUKEE — Hillary Clinton, scrambling to recover from her double-digit defeat in the New Hampshire primary, repeatedly challenged the trillion-dollar policy plans of Bernie Sanders at their presidential debate on Thursday night and portrayed him as a big talker who needed to "level" with voters about the difficulty of accomplishing his agenda.

Foreign affairs also took on unusual prominence as Mrs. Clinton sought to underscore her experience and Mr. Sanders extolled her judgment on Libya and Iraq, as well as her previous praise of former Secretary of State Henry A. Kissinger. But Mrs. Clinton was frequently on the offensive as well, seizing an opportunity to talk about leaders she admired and turning it against Mr. Sanders by hashing his past criticism of President Obama — a remark that Mr. Sanders called a "low blow."

With tensions between the two Democrats becoming increasingly obvious, the debate was full of new lines of attack from Mrs. Clinton, who faces pressure to



A worker installed a baffle in 2010 to control light in the Laser Interferometer Gravitational-Wave Observatory in Hanford, Wash.

Long in Clinton's Corner, Blacks Notice Sanders

By RICHARD FUSSETT

ORANCBURG, S.C. — When Helen Dulev was asked whom

Courted Hard in South Carolina, Loyalists

candidate she barely knew. "It makes me feel good," she said, chuckling, "that young people are listening to the elderly peo-

Last Occupier In Rural Oregon Is Coaxed Out

WITH FAINT CHIRP, SCIENTISTS PROVE EINSTEIN CORRECT

A RIPPLE IN SPACE-TIME

An Echo of Black Holes Colliding a Billion Light-Years Away

By DENNIS OVERBYE

A team of scientists announced on Thursday that they had heard and recorded the sound of two black holes colliding a billion light-years away, a fleeting chirp that fulfilled the last prediction of Einstein's general theory of relativity.

That faint rising tone, physicists say, is the first direct evidence of gravitational waves, the ripples in the fabric of space-time that Einstein predicted a century ago. It completes his vision of a universe in which space and time are interwoven and dynamic, able to stretch, shrink and jiggle. And it is a ringing confirmation of

the nature of black holes, the bottomless gravitational pits from which not even light can escape, which were



Le sorgenti cosmiche di onde radio sono debolissime,
servono grandi aree
di raccolta dei segnali:

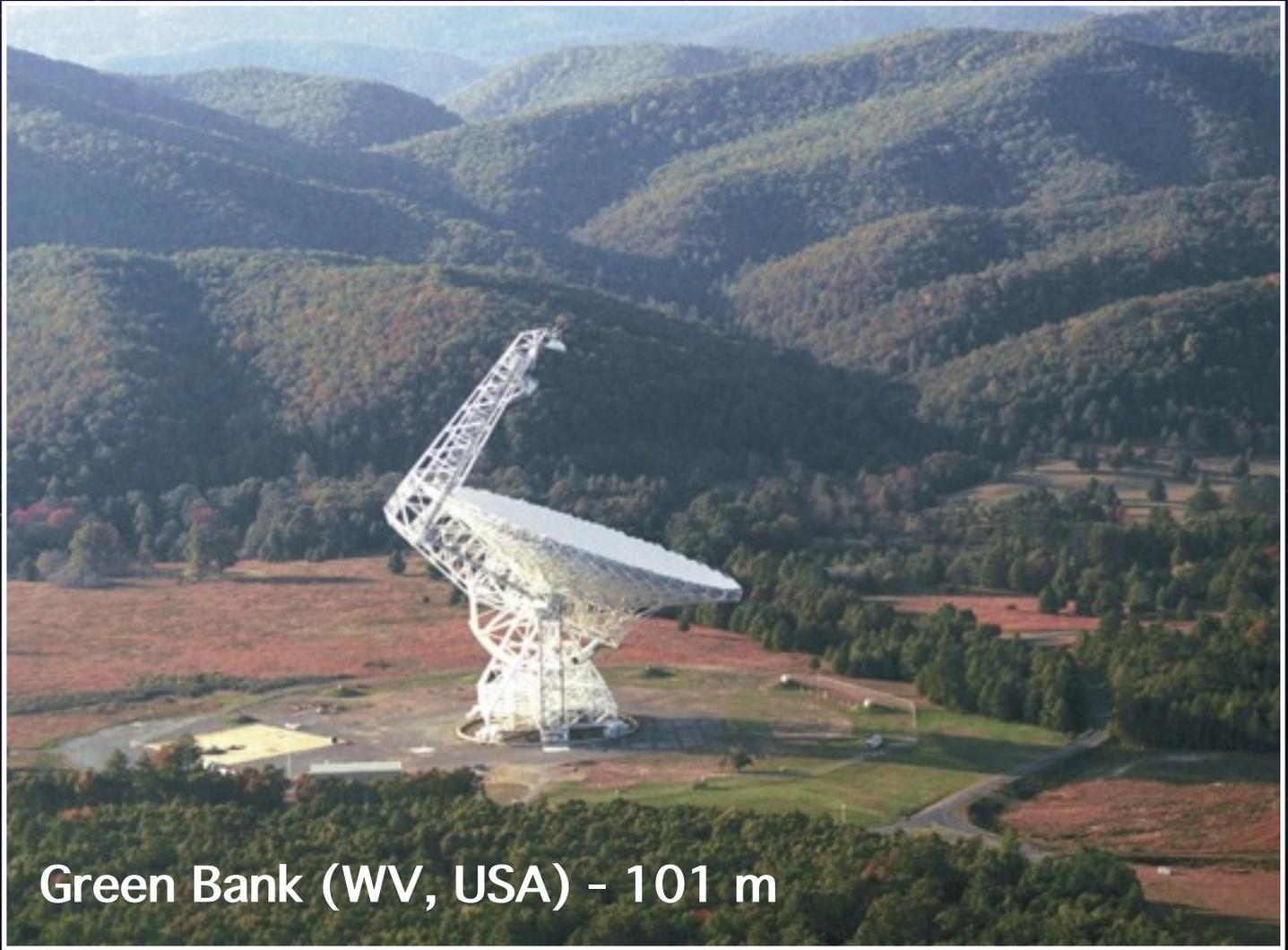




Effelsberg (DE) - 100 m



Jodrell Bank (UK) - 76 m



Green Bank (WV, USA) - 101 m

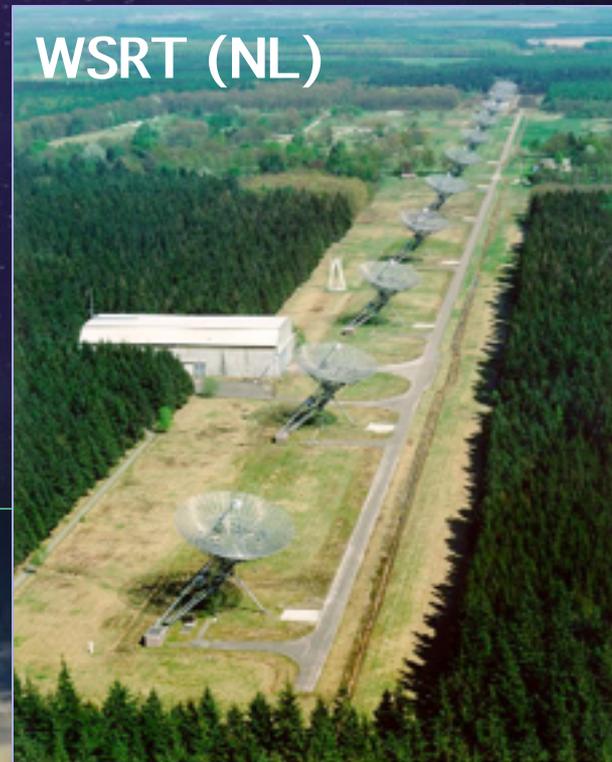


Arecibo (PR, USA) - 300 m

ATCA (NSW, Australia)



WSRT (NL)

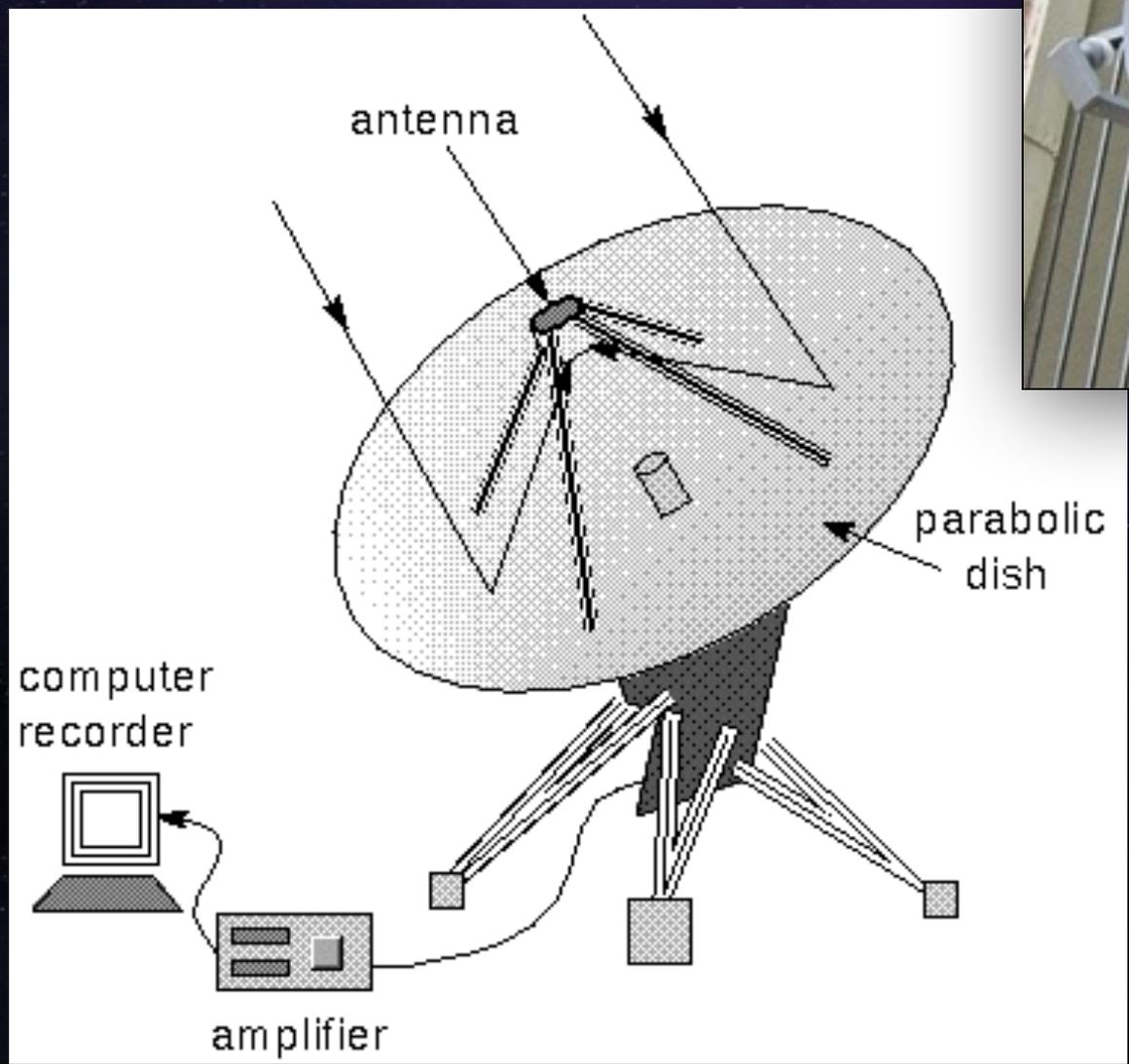


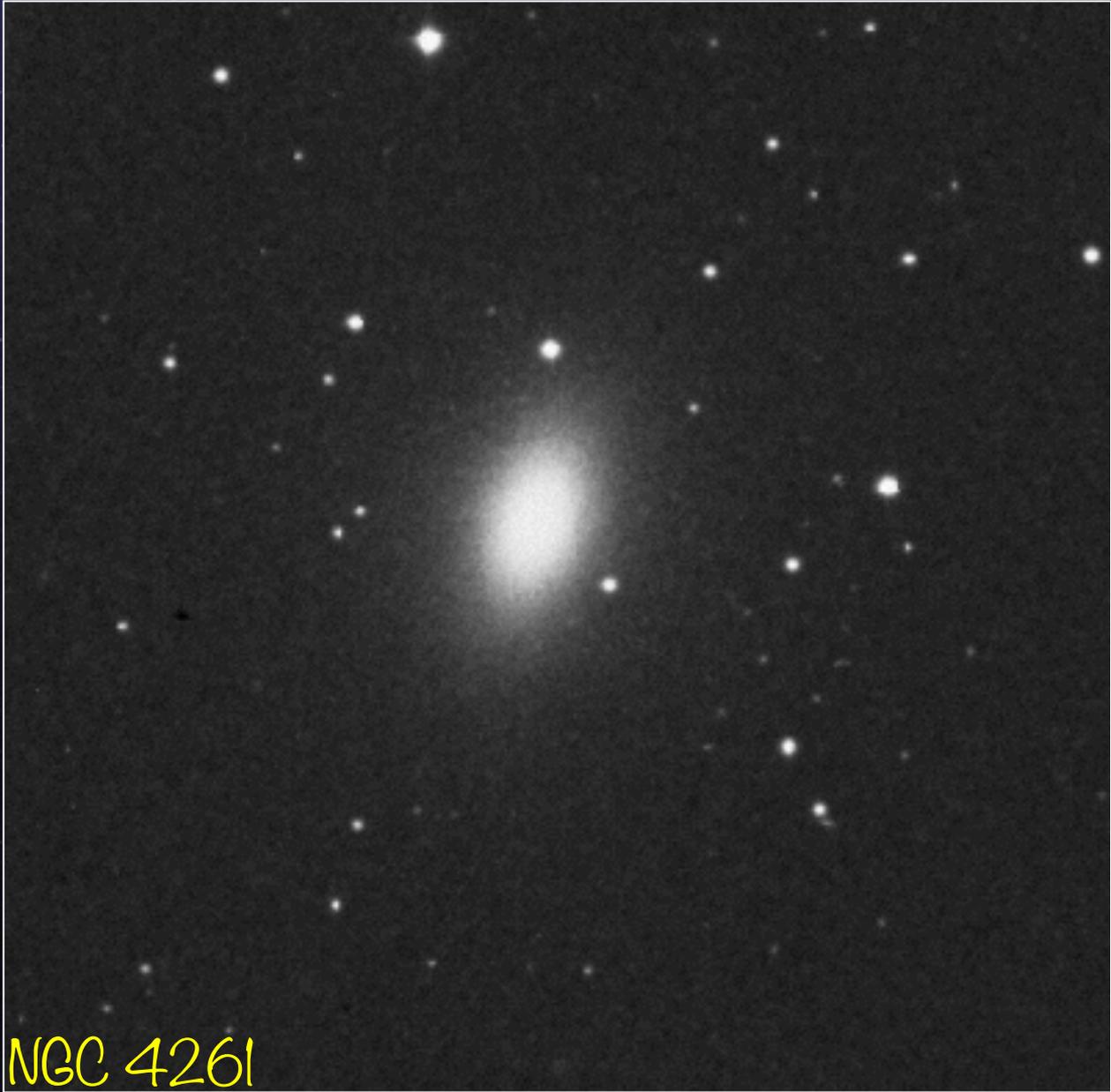
VLA (NM, USA)



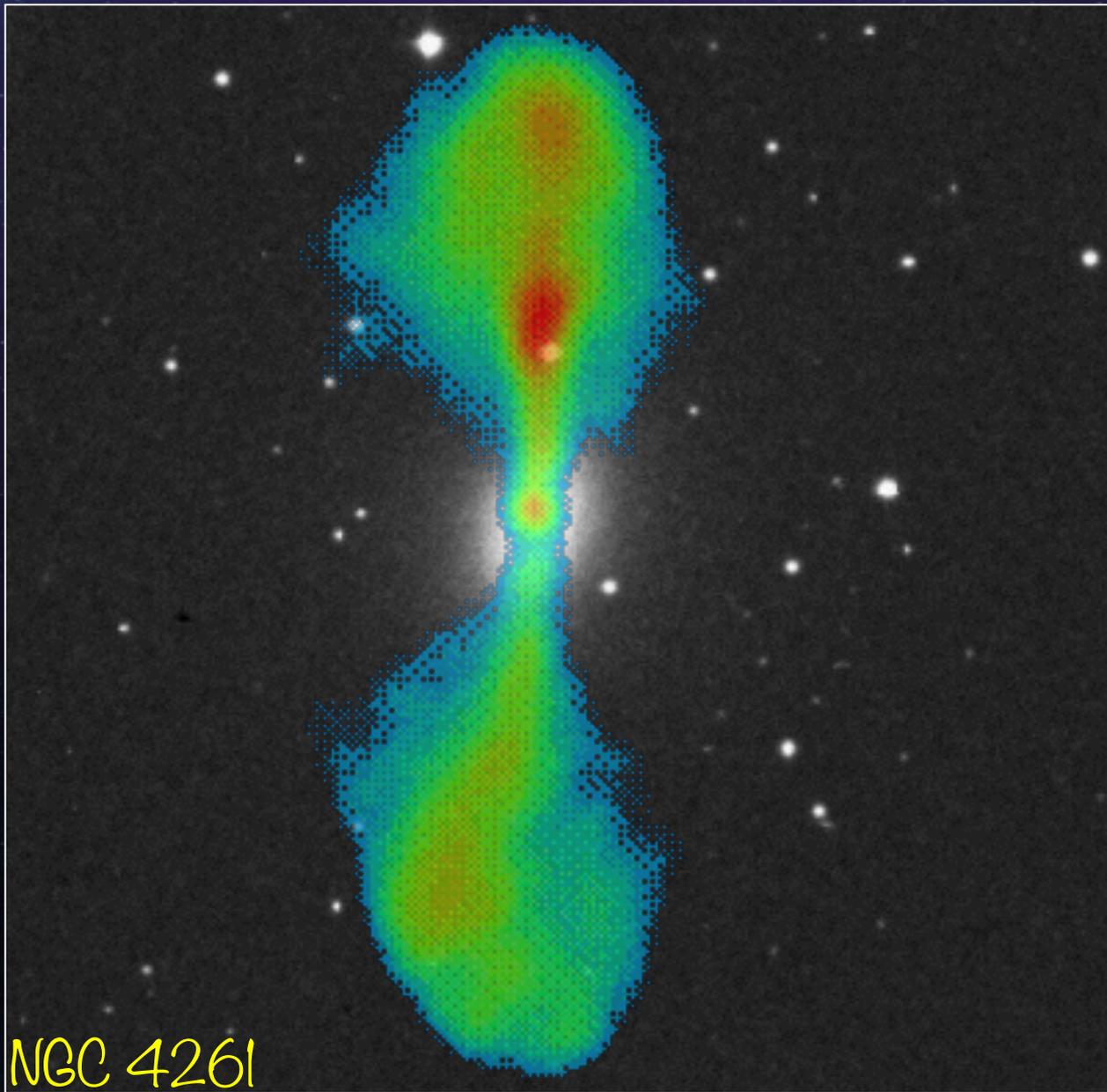
I radioastronomi non ascoltano le onde radio!







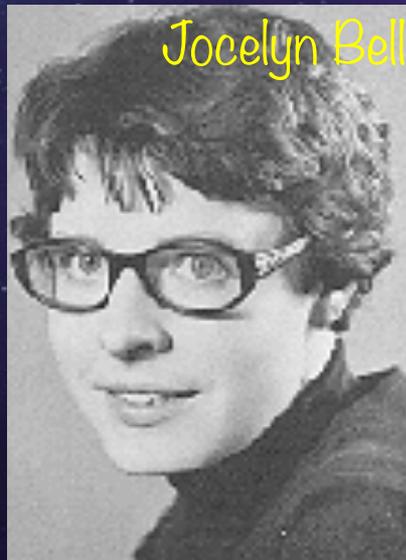
NGC 4261



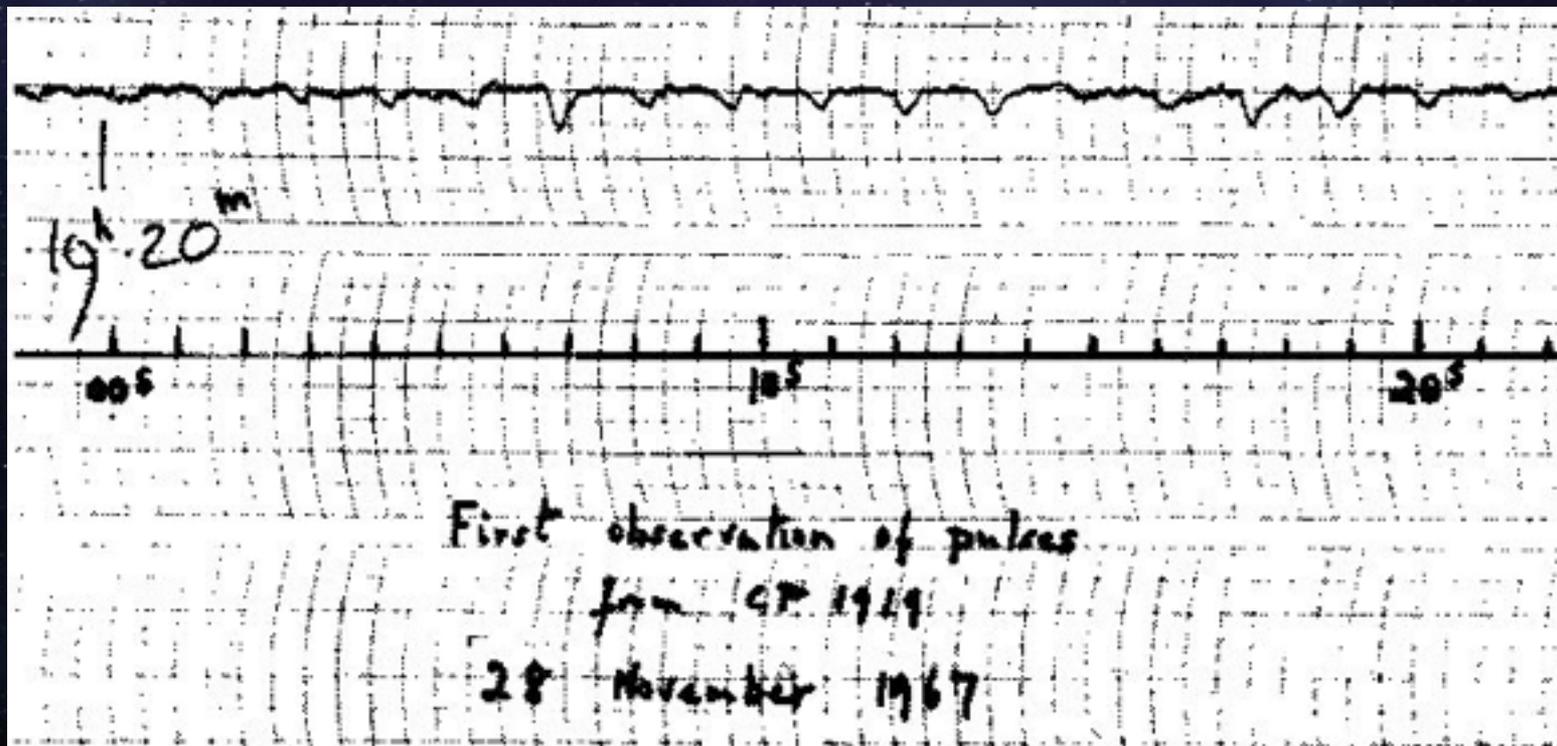
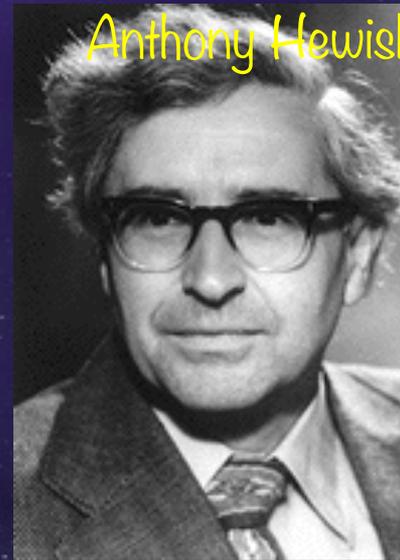
NGC 4261

Le Pulsar

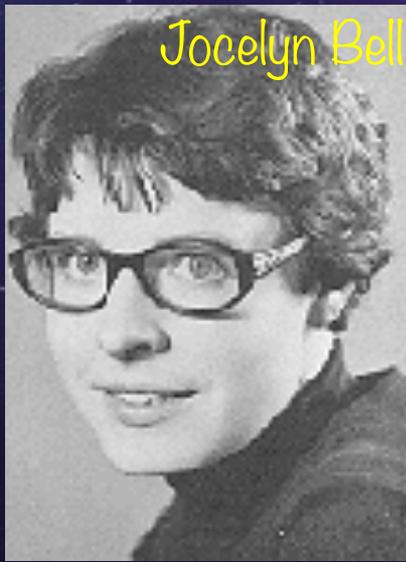
Jocelyn Bell



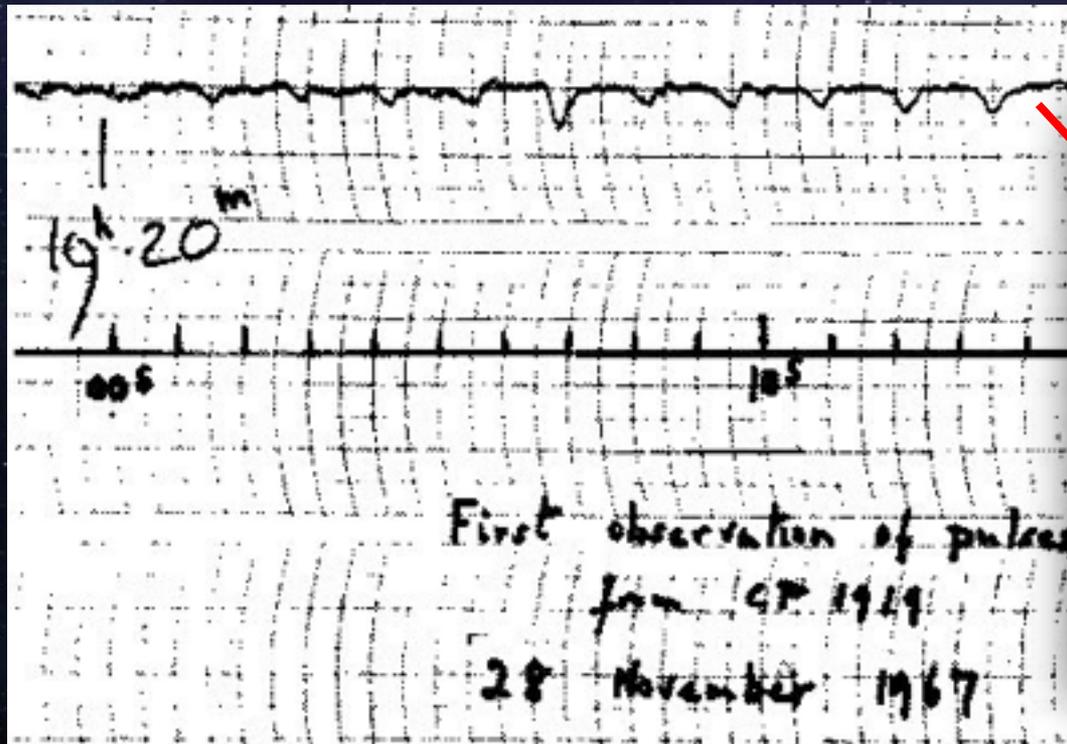
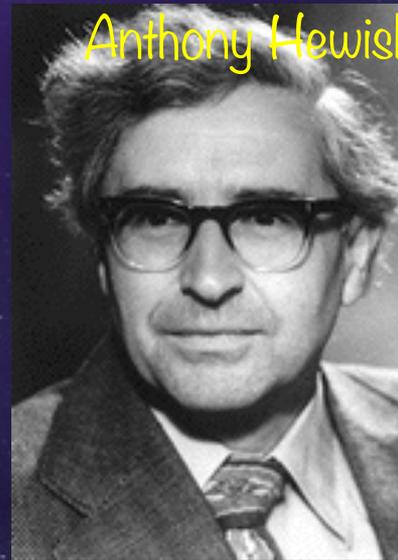
Anthony Hewish



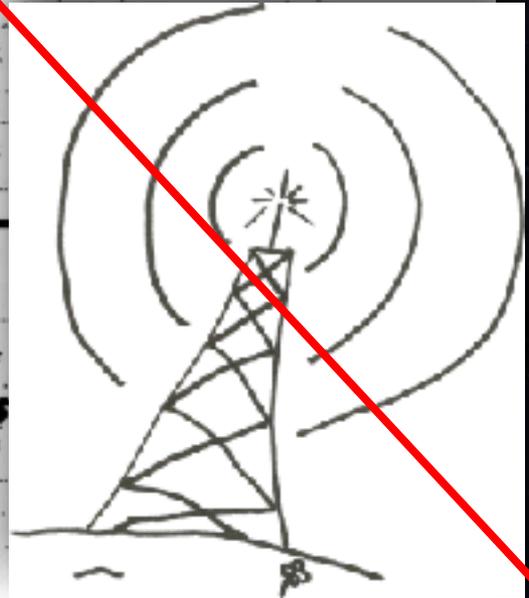
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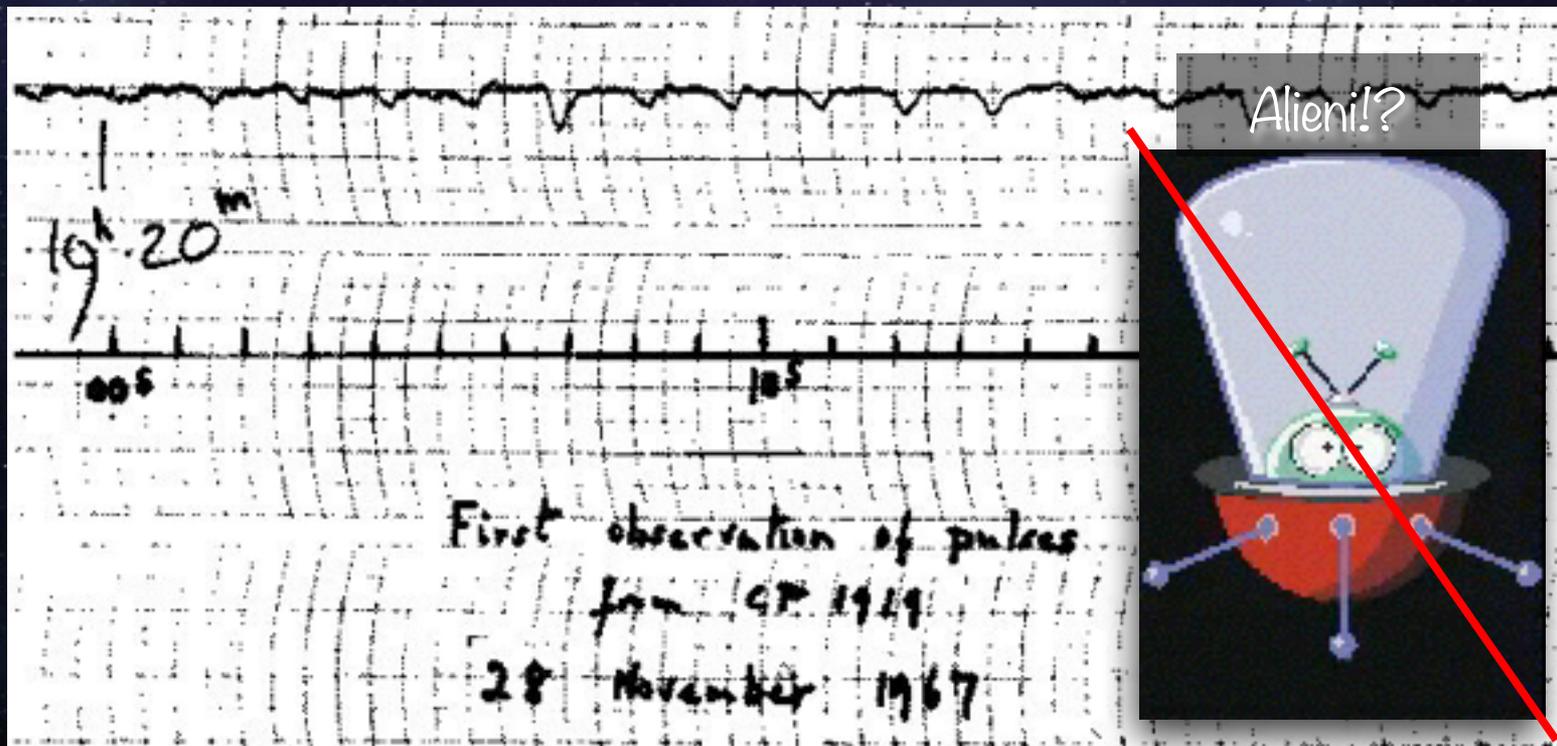
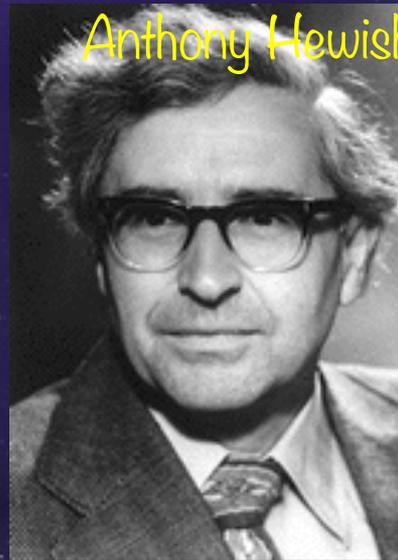
Interferenze terrestri?



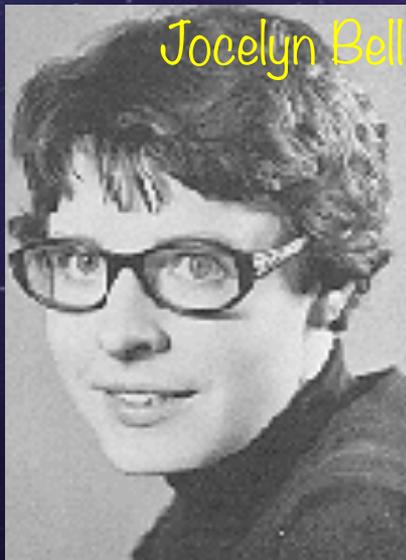
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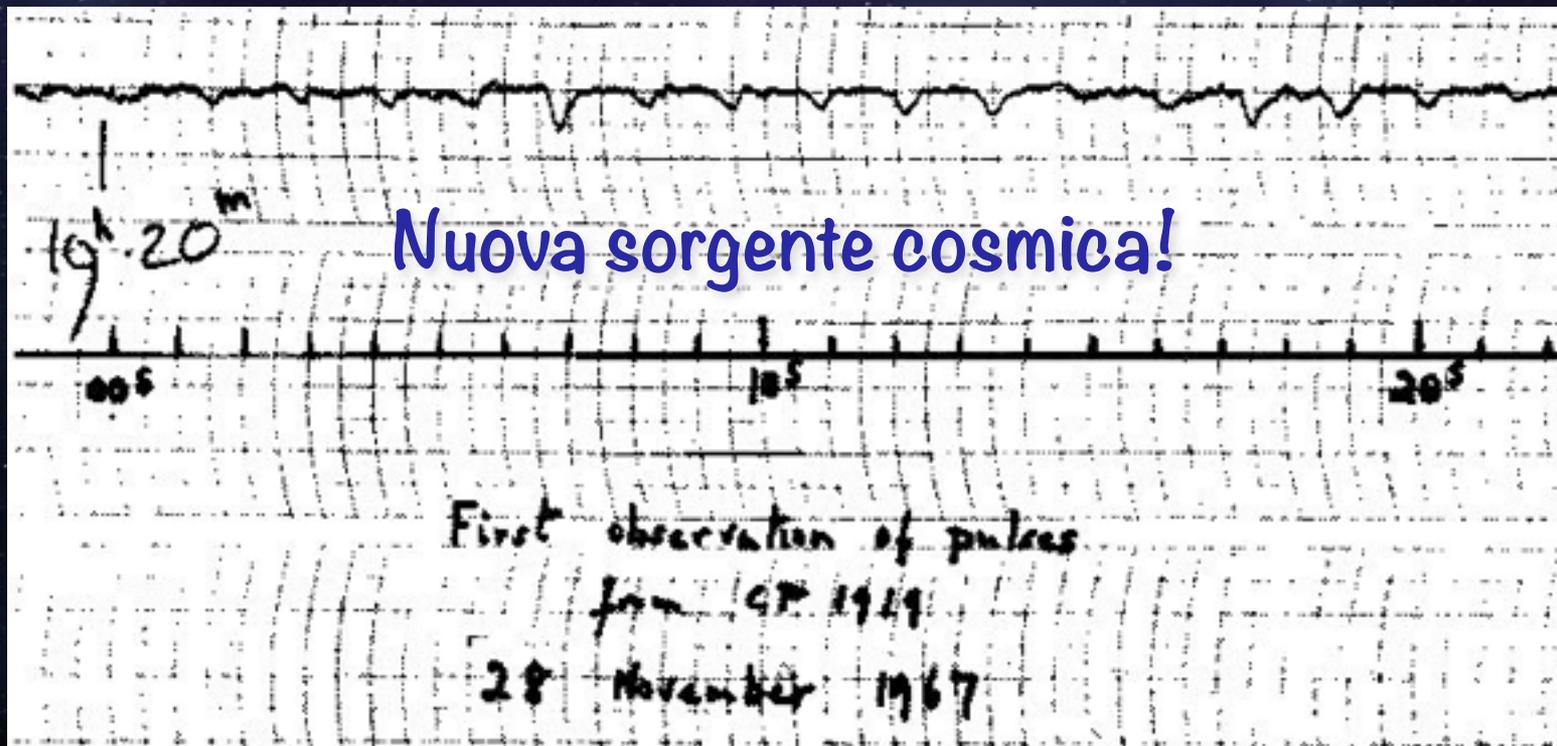
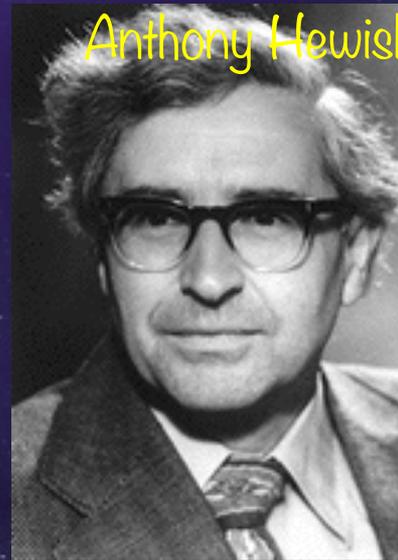
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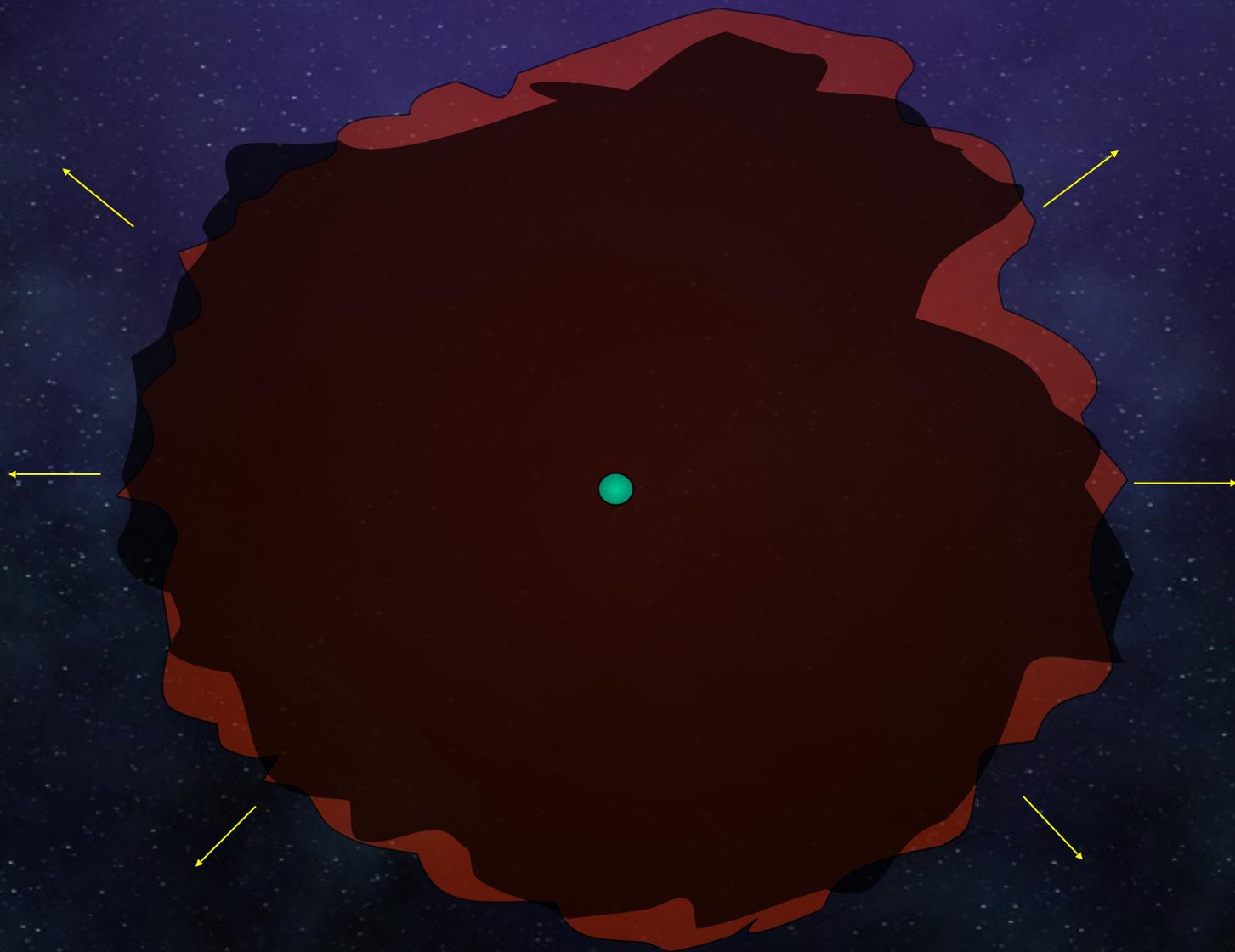


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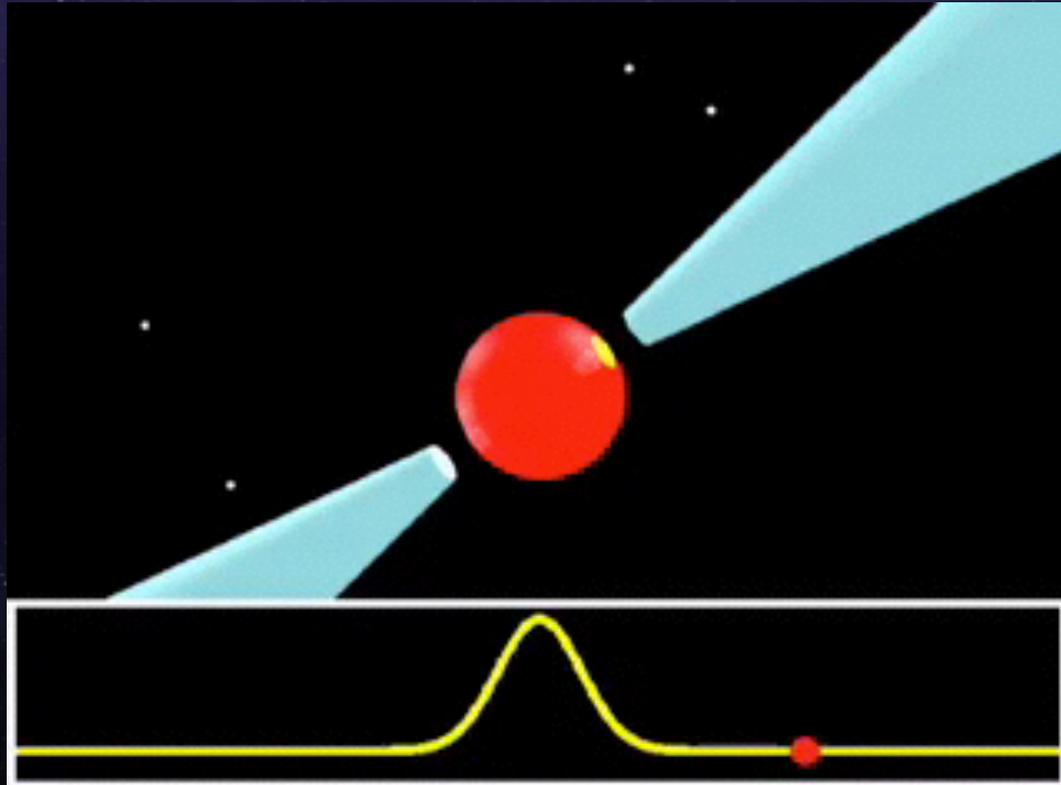
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Rimane una "stella di neutroni"



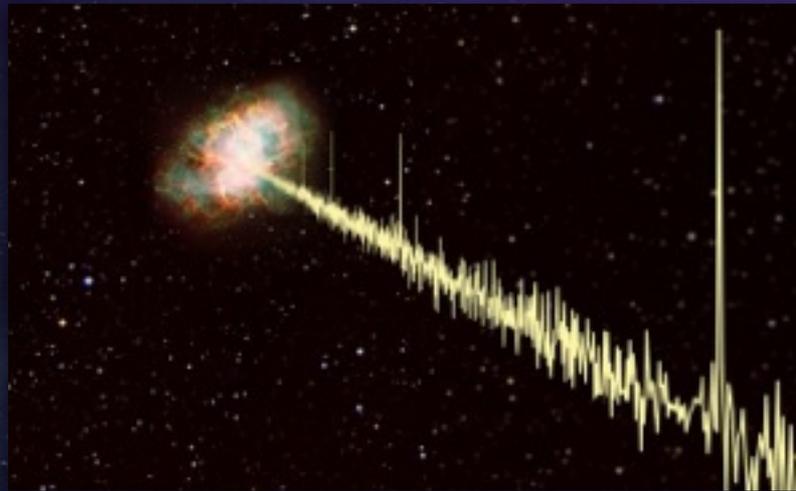


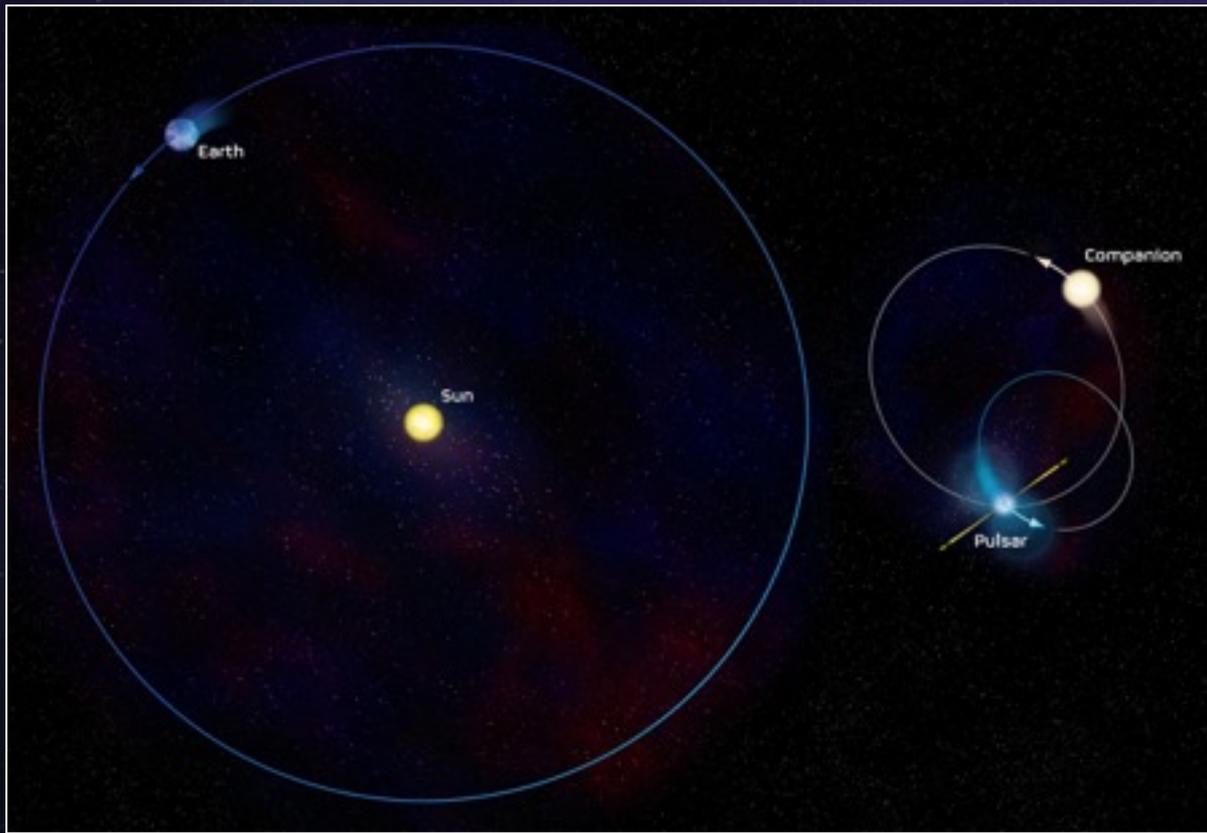
Dal 1967 ad oggi scoperte più di 2500 pulsar

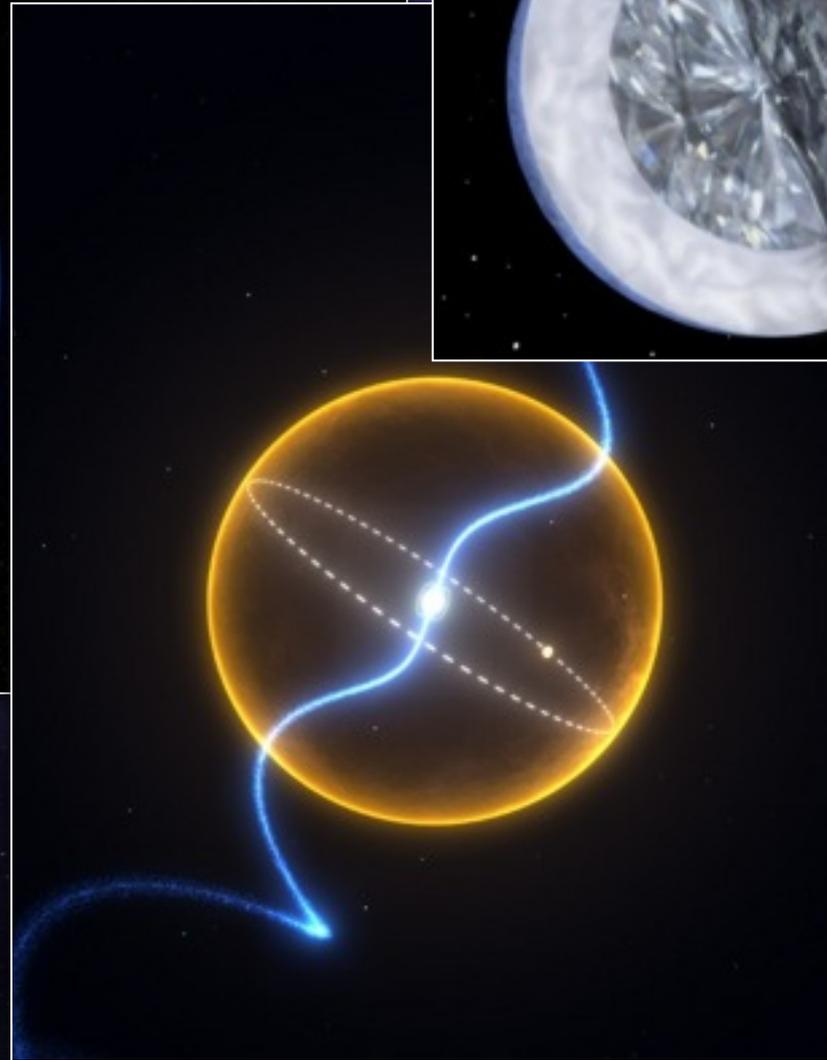
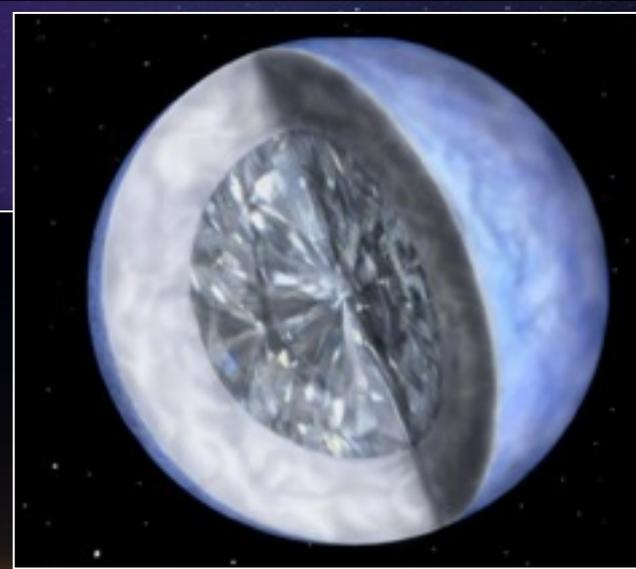
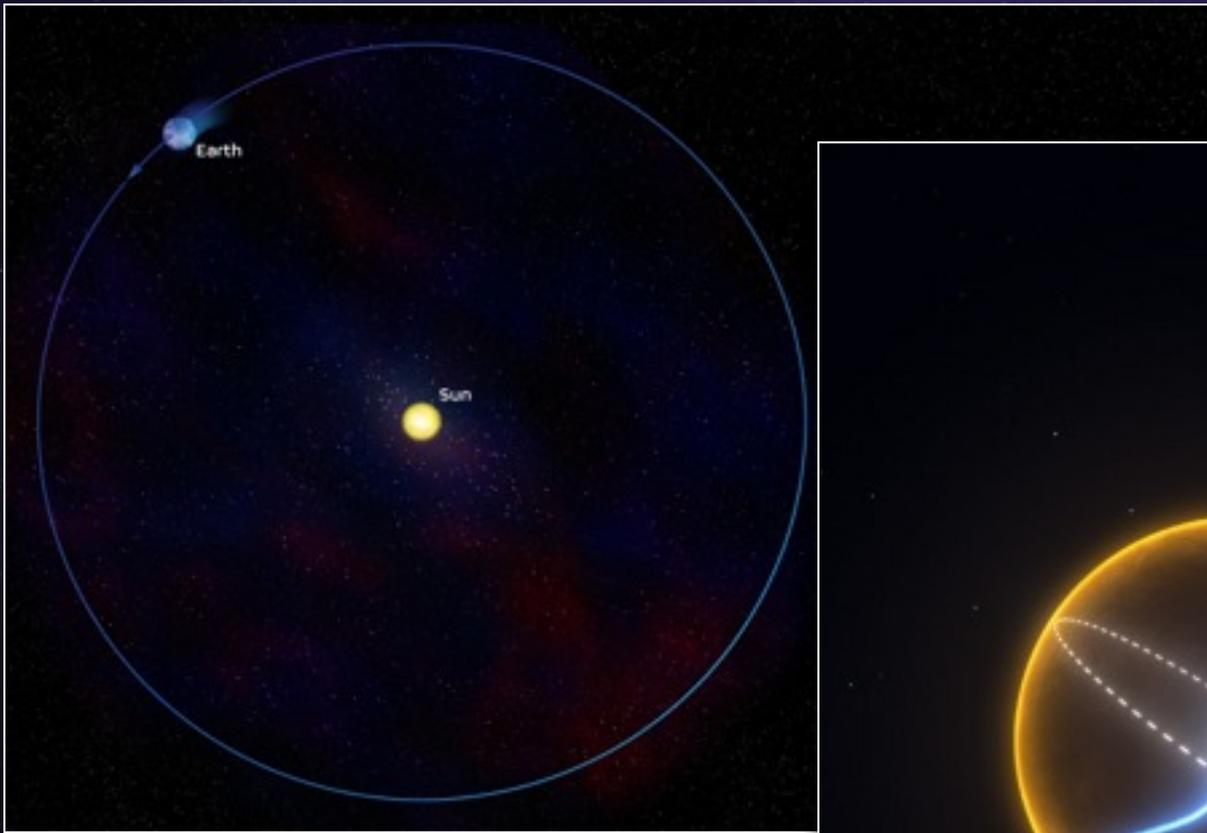




0.00155780652149318686248 ± 0.00000000000000000000000003 sec



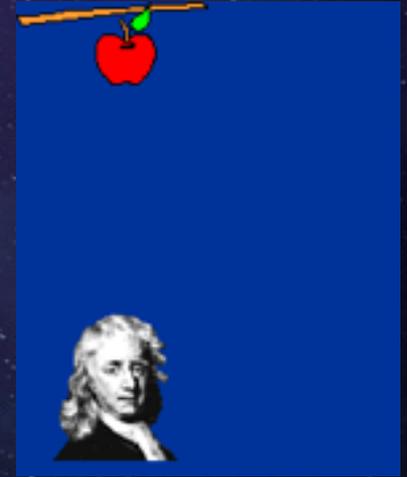




(Pulsar in)
sistemi binari

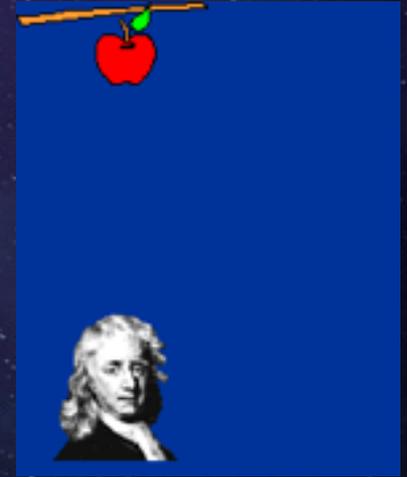
Secondo Newton, una massa M (la nostra Terra) esercita su una massa m (la mela di Newton, posta ad una distanza D dalla terra) una forza data dalla formula:

$$F = G \frac{M}{D^2} m$$



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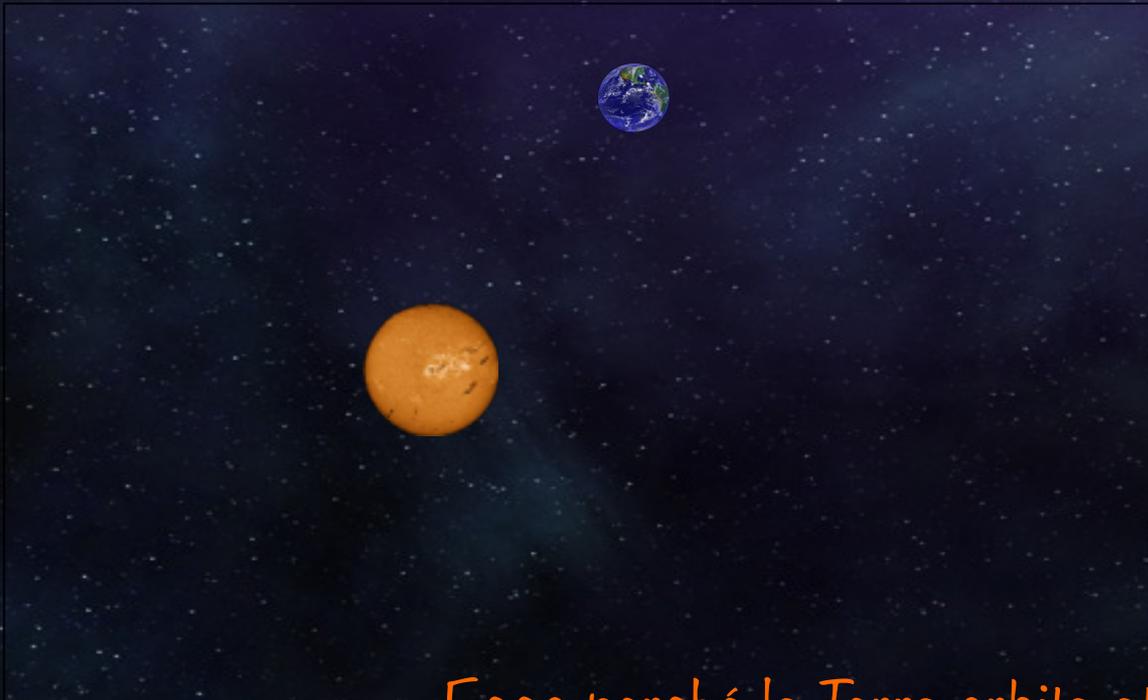
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Ecco perché la mela cade sulla terra !

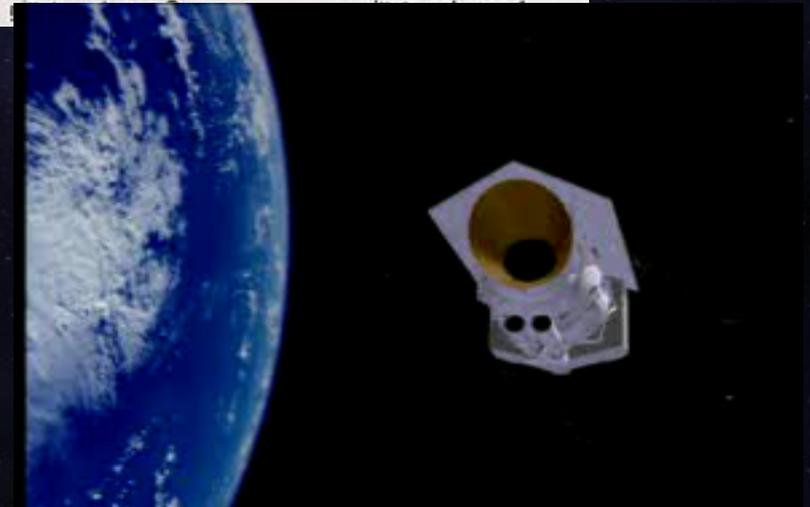
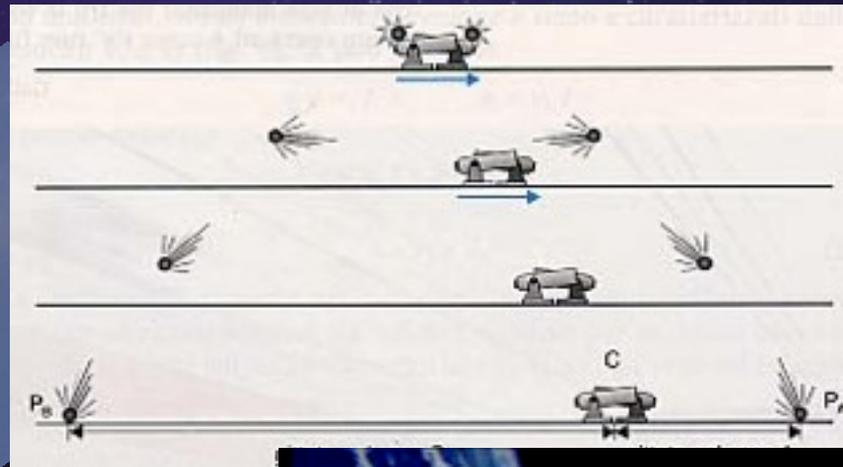
Secondo Newton, una massa M (il Sole) esercita su una massa m (la nostra Terra, posta ad una distanza D dal Sole) una forza data dalla formula:

$$F = G \frac{M}{D^2} m$$

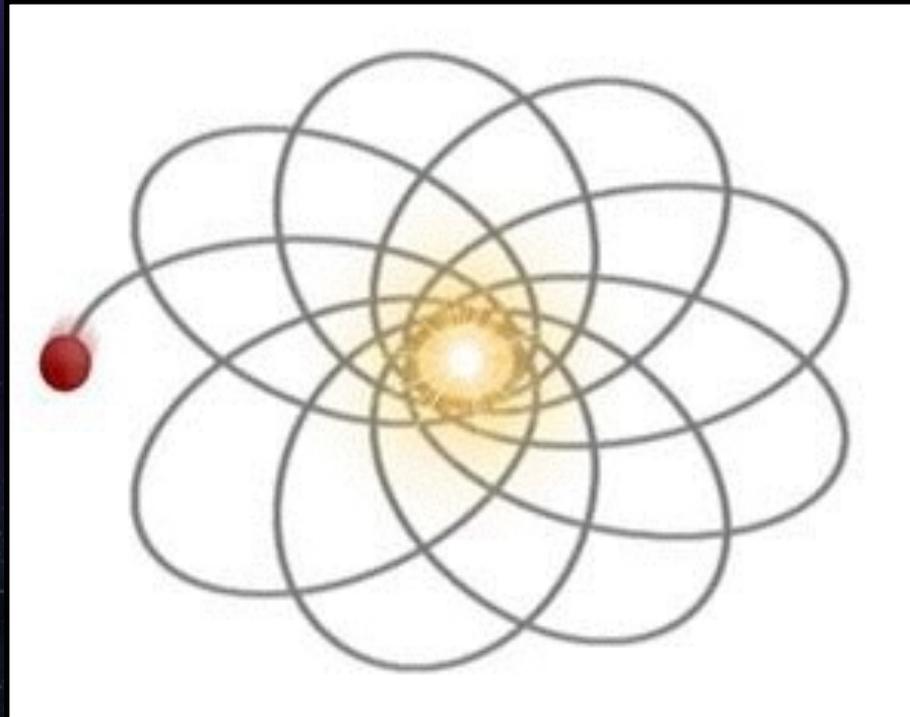


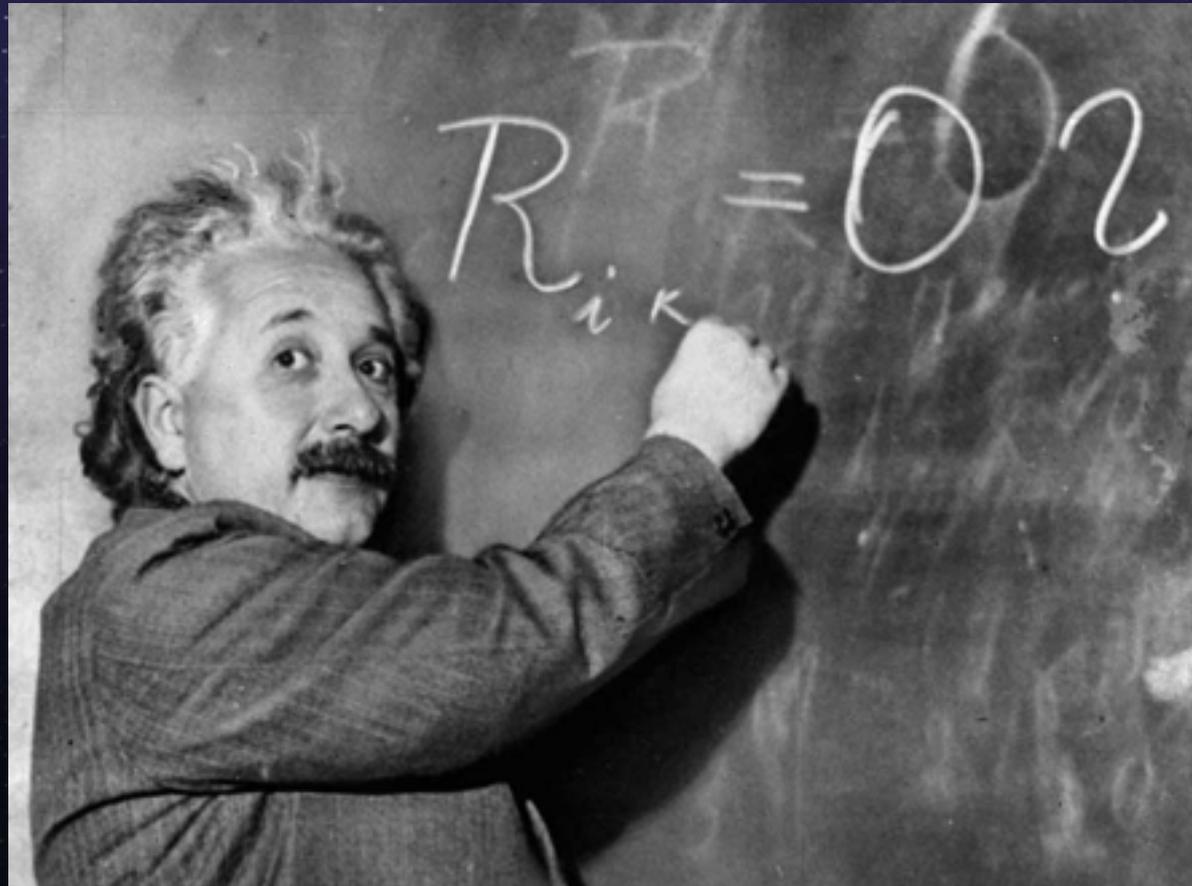
Ecco perché la Terra orbita attorno al Sole!

Moto dei razzi, dei satelliti artificiali, delle palle di cannone, etc...
permettono la verifica delle leggi di Newton nei laboratori terrestri..



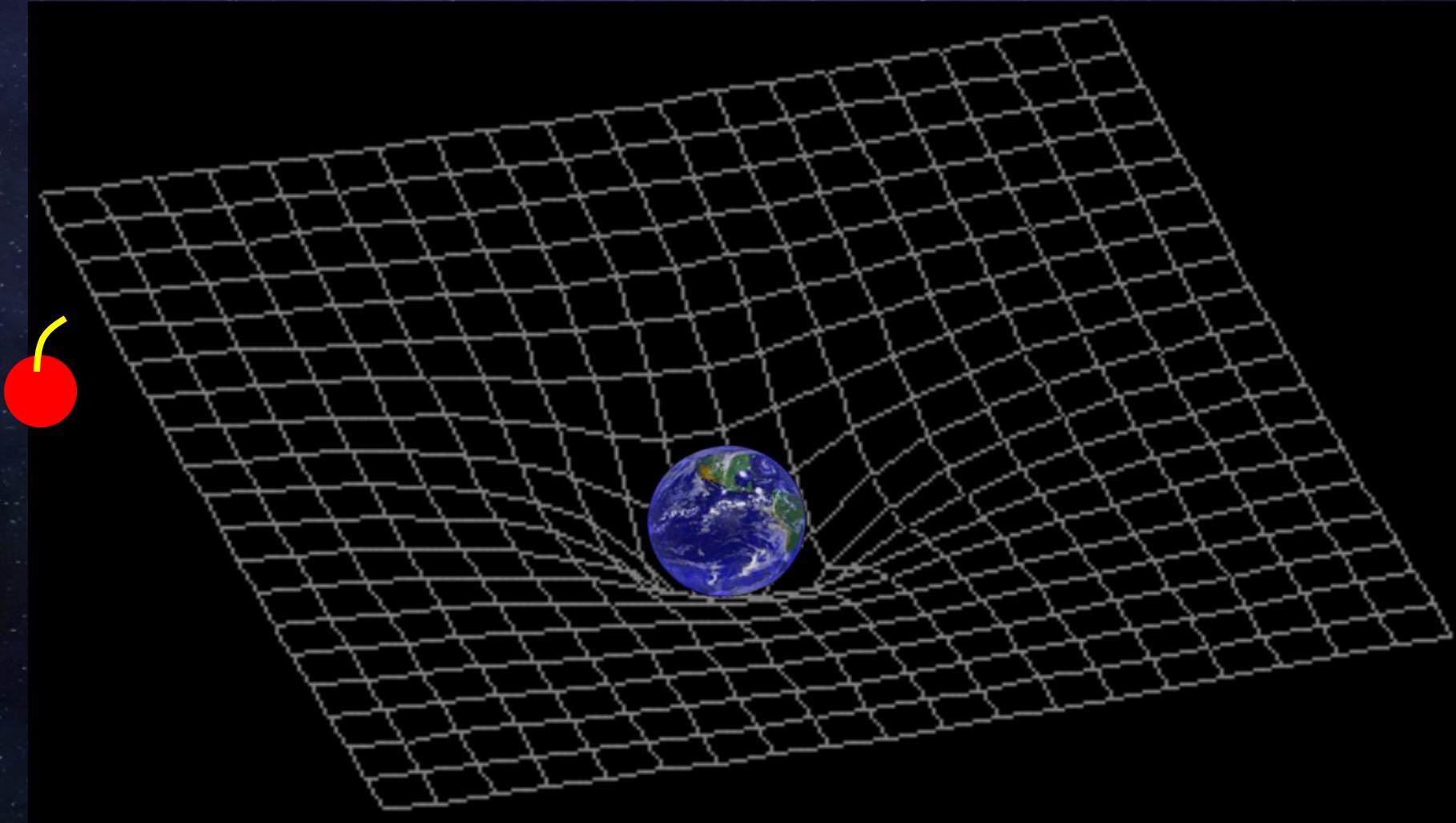
...non tutto torna



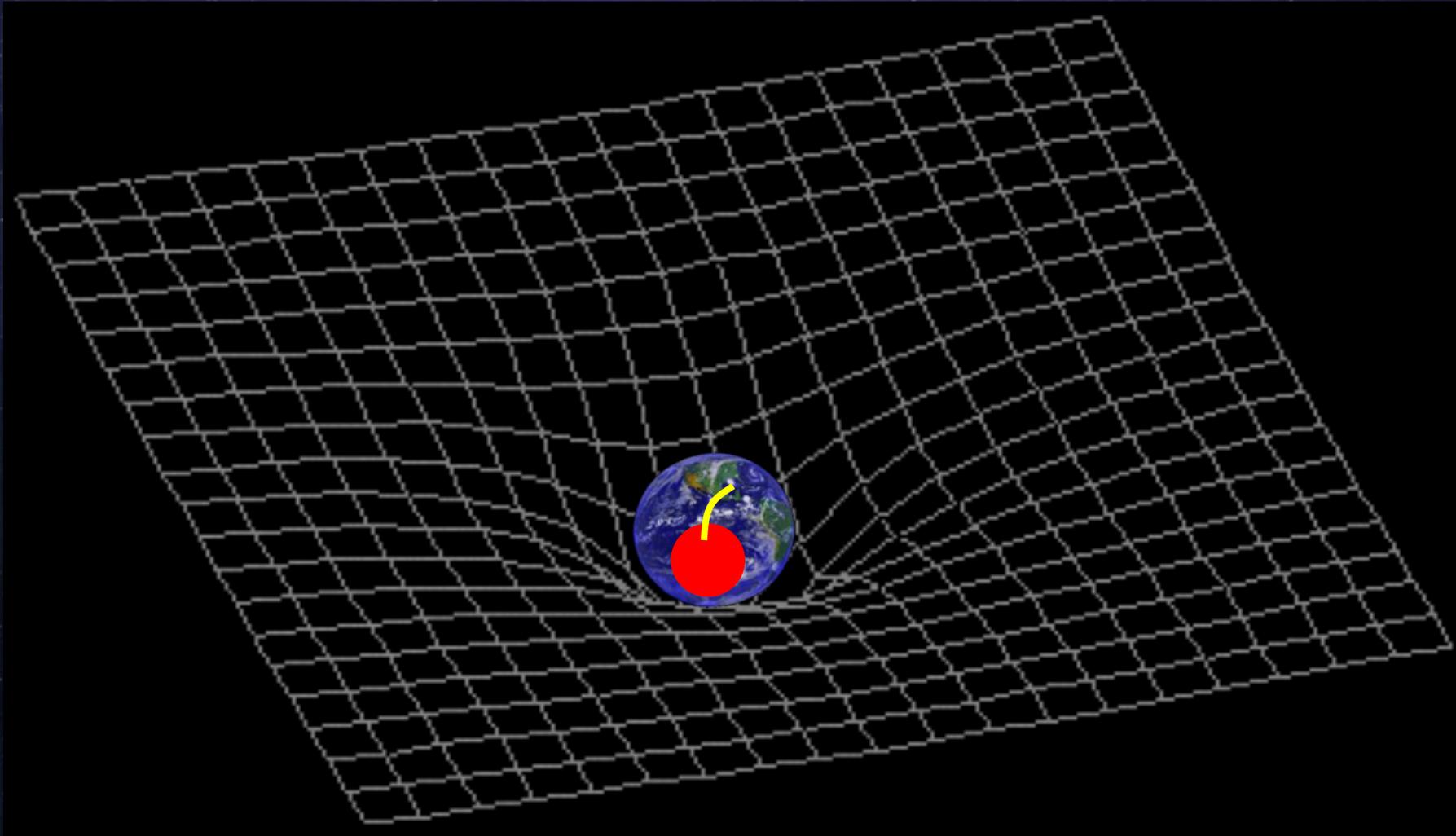


Einstein (1879-1955)

Secondo Einstein, una massa M (la nostra Terra) deforma lo spazio circostante. Una massa m (la nostra mela posta ad una distanza D dalla terra) “scivola” nelle deformazioni dello spazio

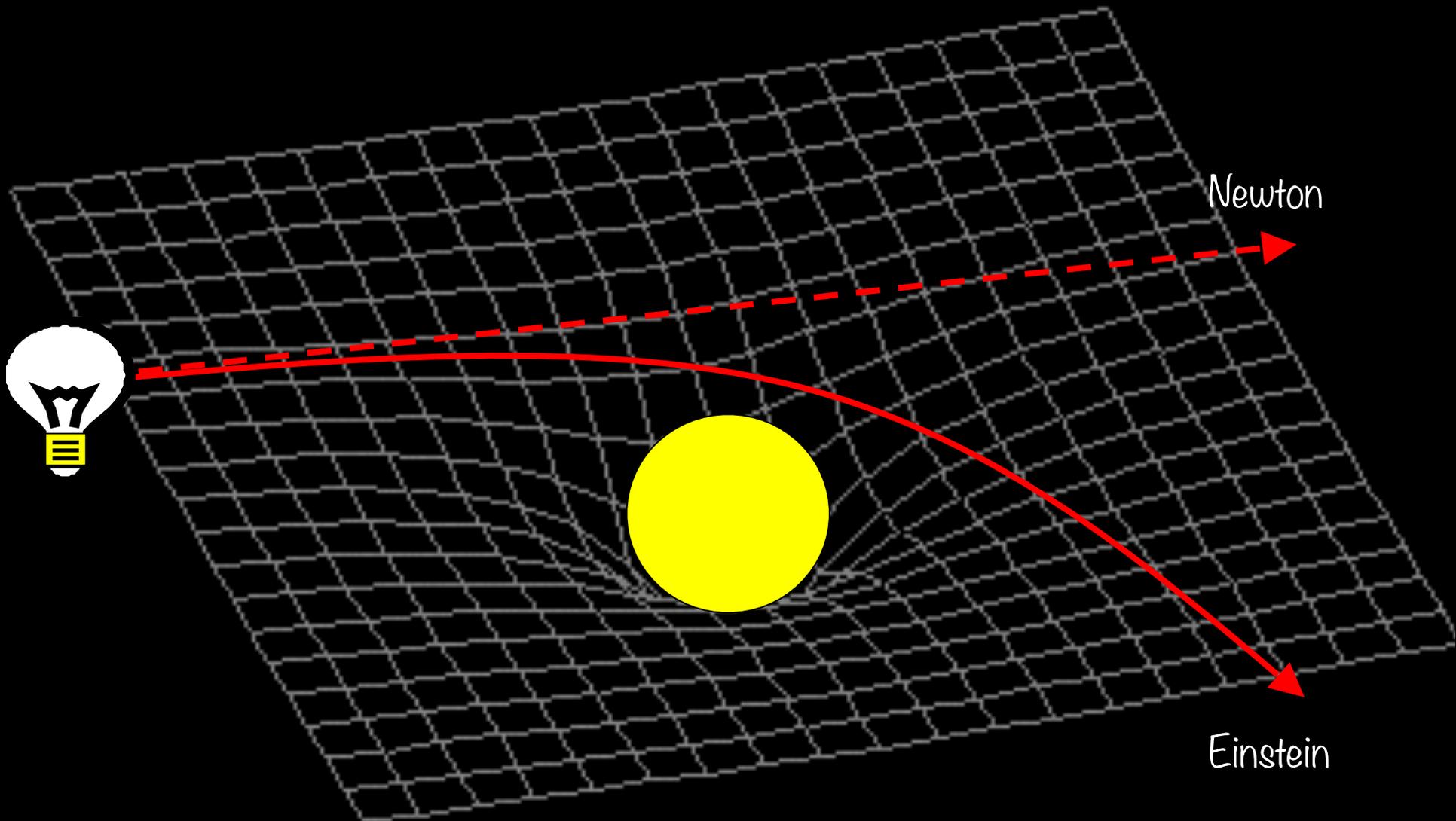


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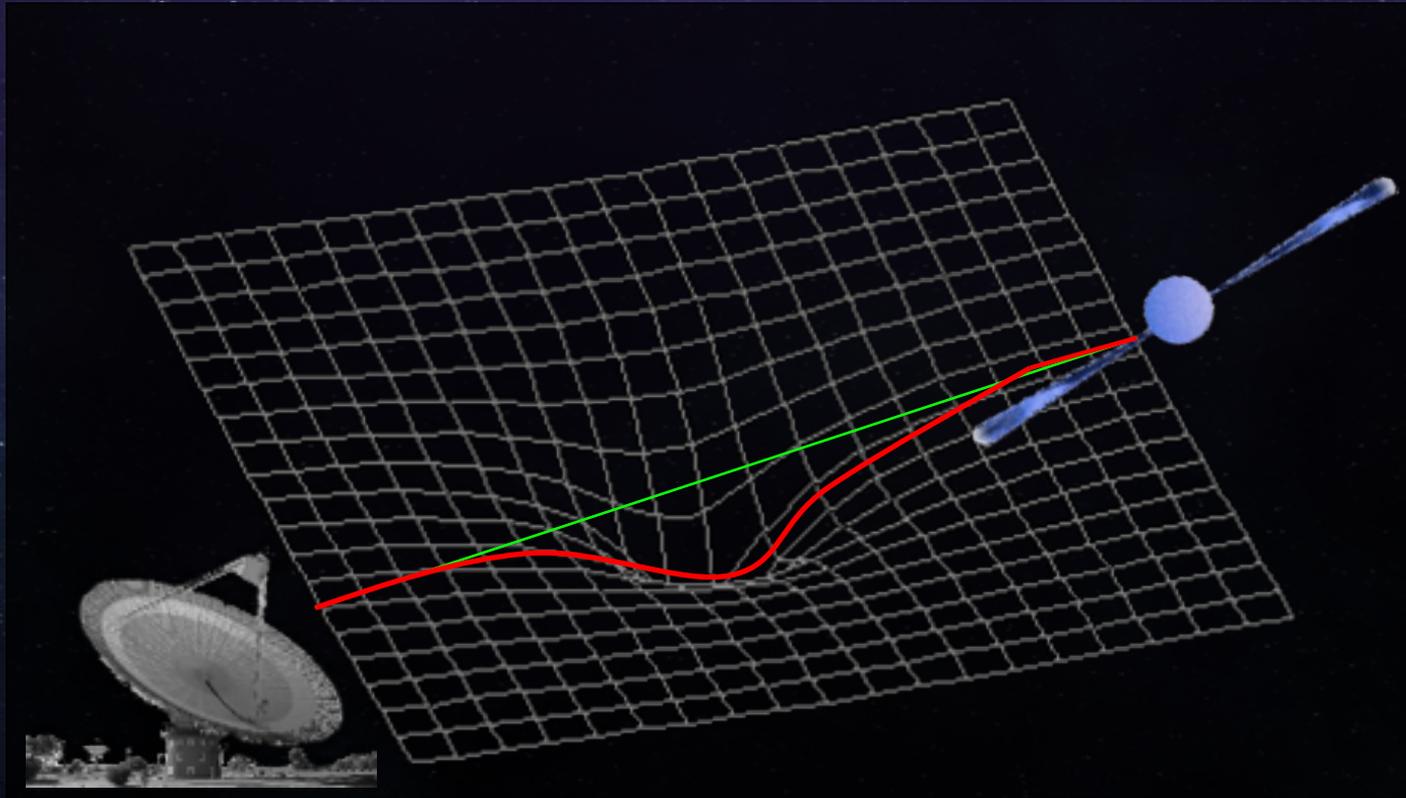


Ecco perché la mela cade sulla terra !

Nella teoria di Einstein, una massa è quindi in grado di deflettere un raggio luminoso, ma non nella teoria di Newton !

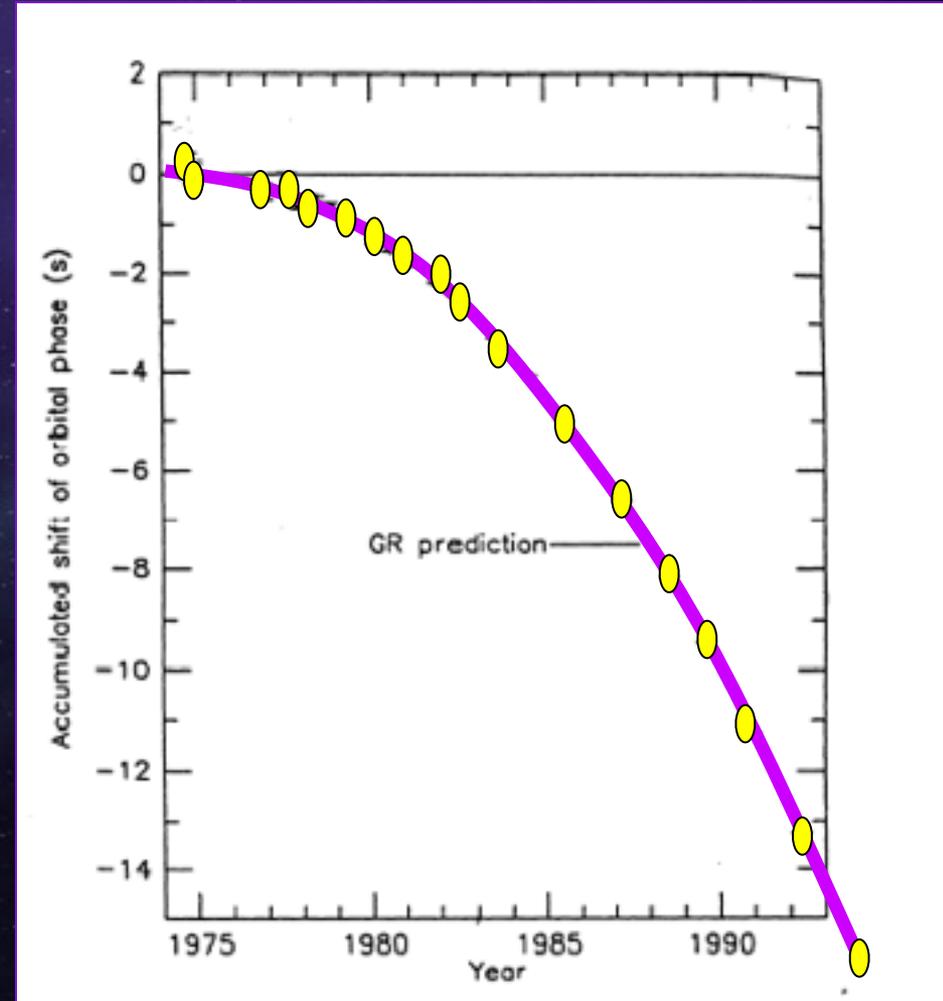


Le Pulsar e Einstein



Laboratorio ideale per testare la teoria di Einstein!

1974: scoperta della prima pulsar in un sistema binario



1993: Premio Nobel a Hulse e Taylor

2003: La scoperta di un sistema binario “super-relativistico”:

La prima pulsar doppia !!!

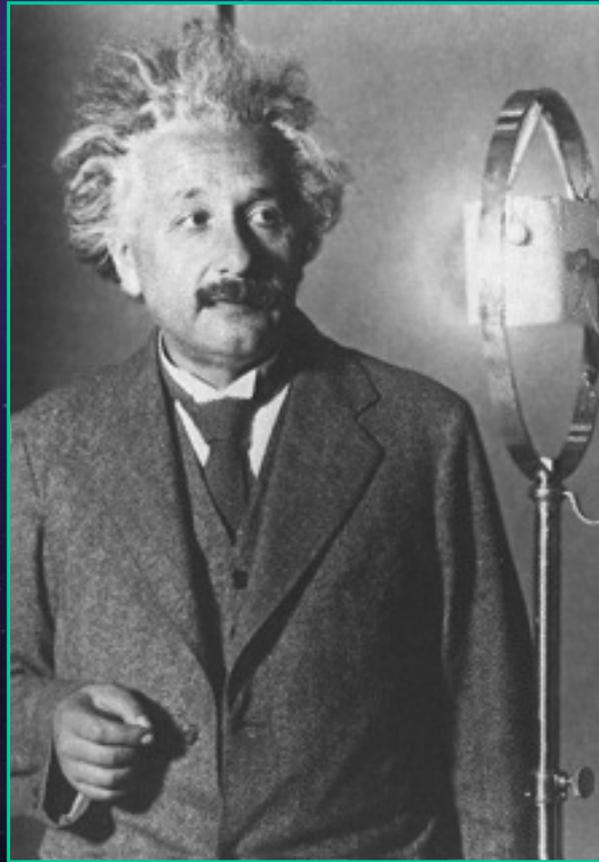
Due pulsar che girano una intorno all'altra in 2.4 ore !!





Misurato in appena **5 giorni** di osservazione!!

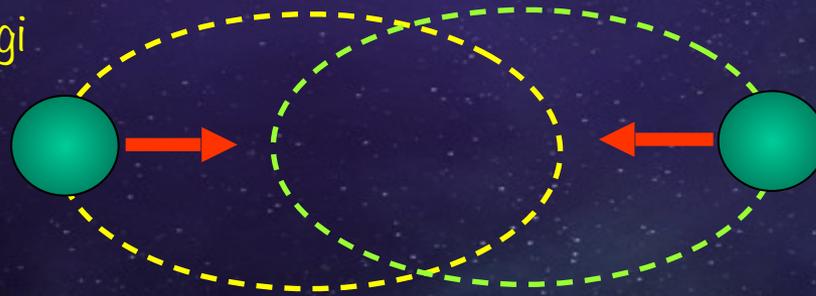
...nella pulsar Doppia abbiamo **DUE** orologi simultaneamente disponibili per studiare la teoria della Relatività Generale



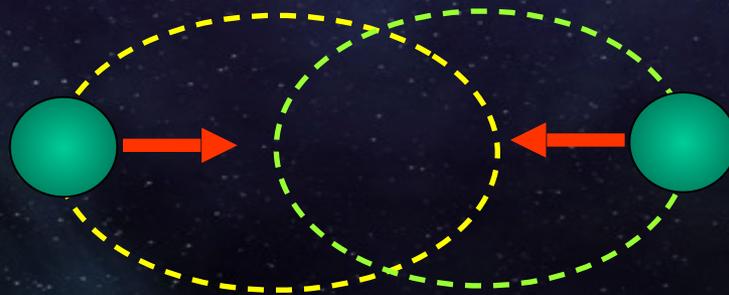
le predizioni di Albert Einstein riflettono il modo di comportarsi della Natura con un errore massimo dello
0.02% !!!!

Dopo appena un paio di anni si è misurato il restringimento dell'orbita:
cambia di circa 7 millimetri al giorno !!

Oggi

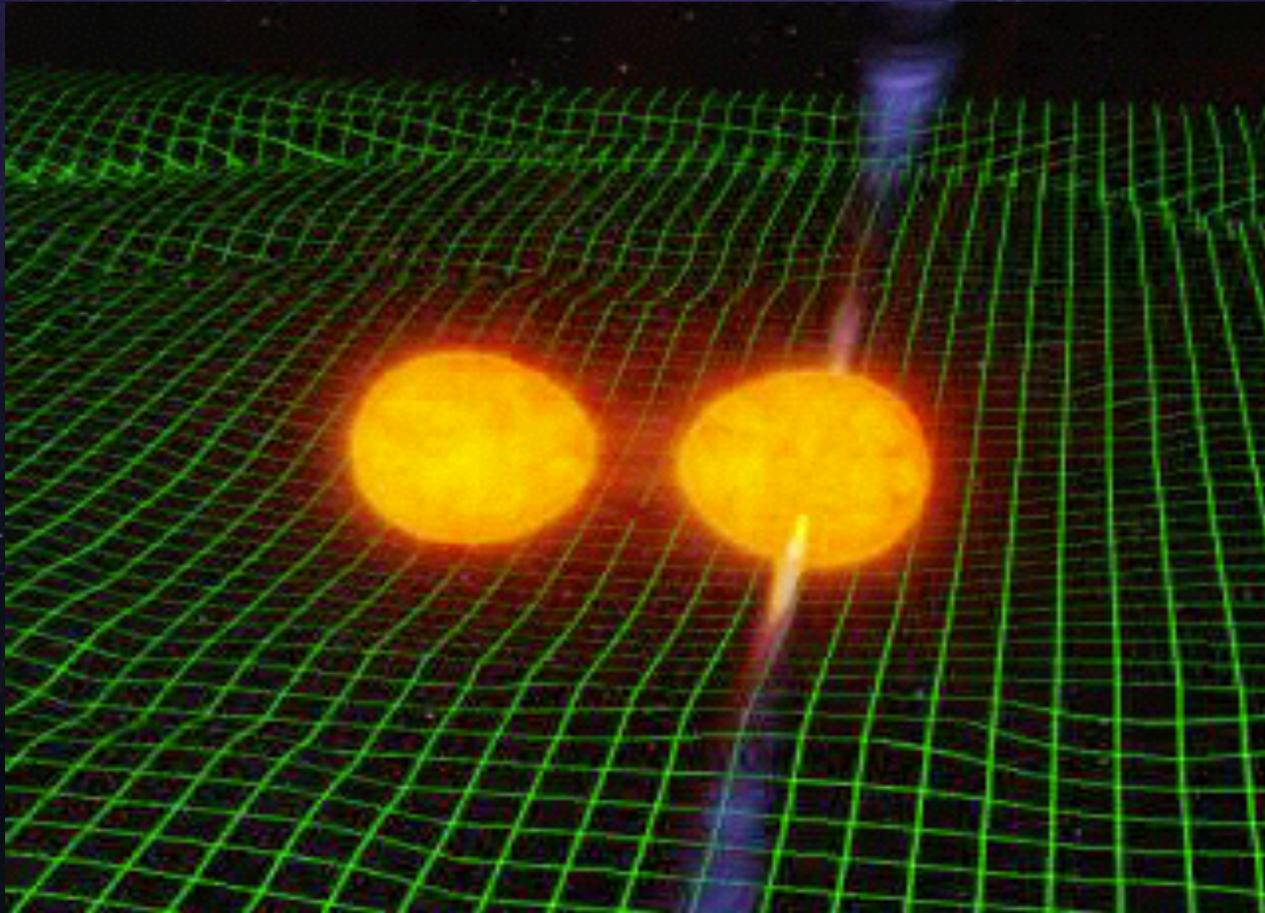


Fra dieci milioni di anni

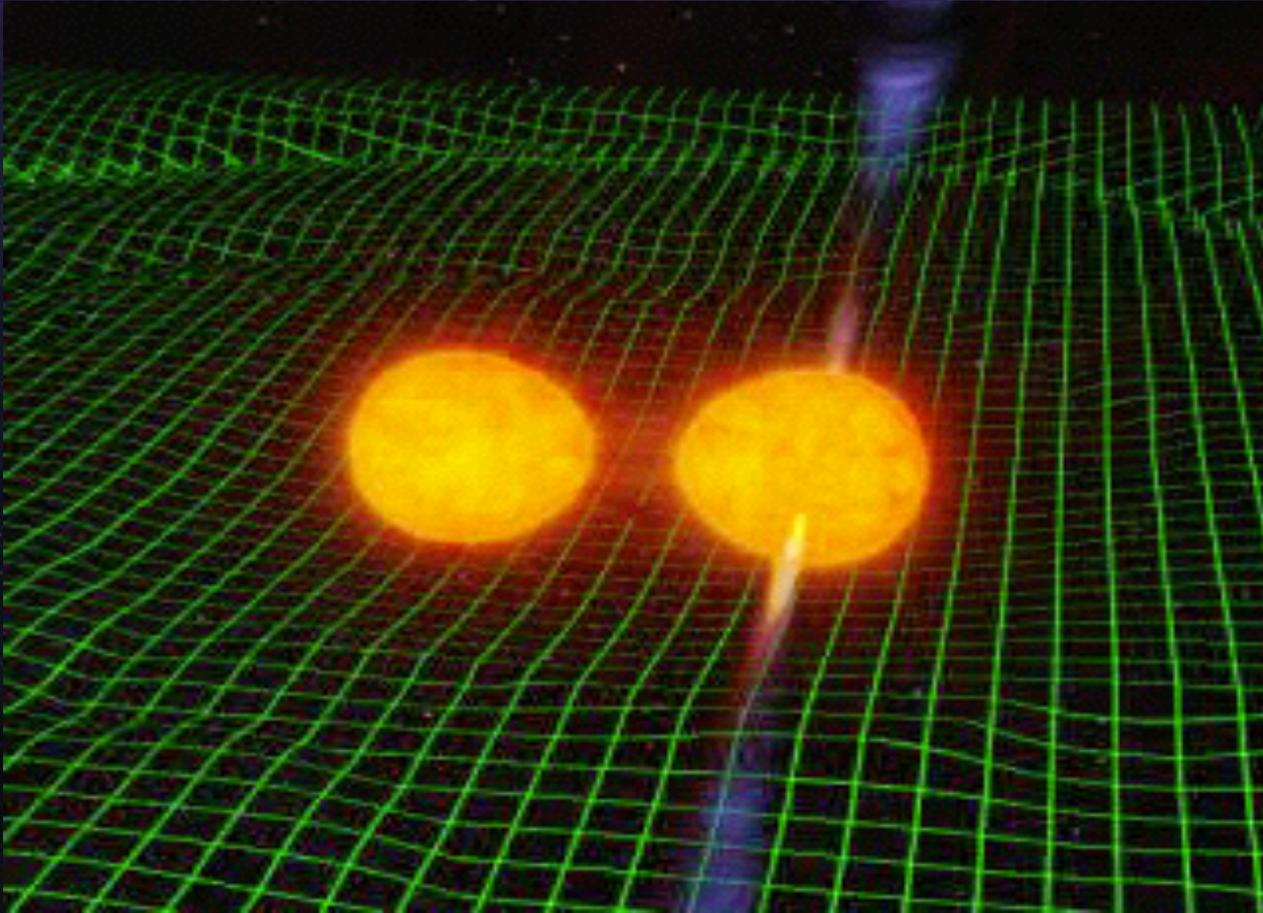


~80 000 km

...e come finirà?



... un nuovo Buco Nero !



© John Rowe Animation

Presto, scoperte come queste, ed altre, saranno
effettuabili con un radiotelescopio tutto italiano

SRT

Sardinia

Radio

Telescope

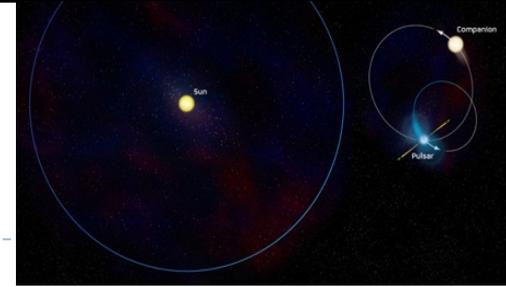


Sergio Poppi



INAF - Osservatorio Astronomico di Cagliari

Come seguirci



SITI WEB:

- www.srt.inaf.it (disponibile la webcam)
- www.oa-cagliari.inaf.it e www.oa-cagliari.inaf.it/divulgazione

FACEBOOK:



Sardinia Radio Telescope



Osservatorio Astronomico di Cagliari



Grazie !!

