

La luce invisibile delle stelle

Come mettere alla prova Einstein con la
radioastronomia



Marta Burgay

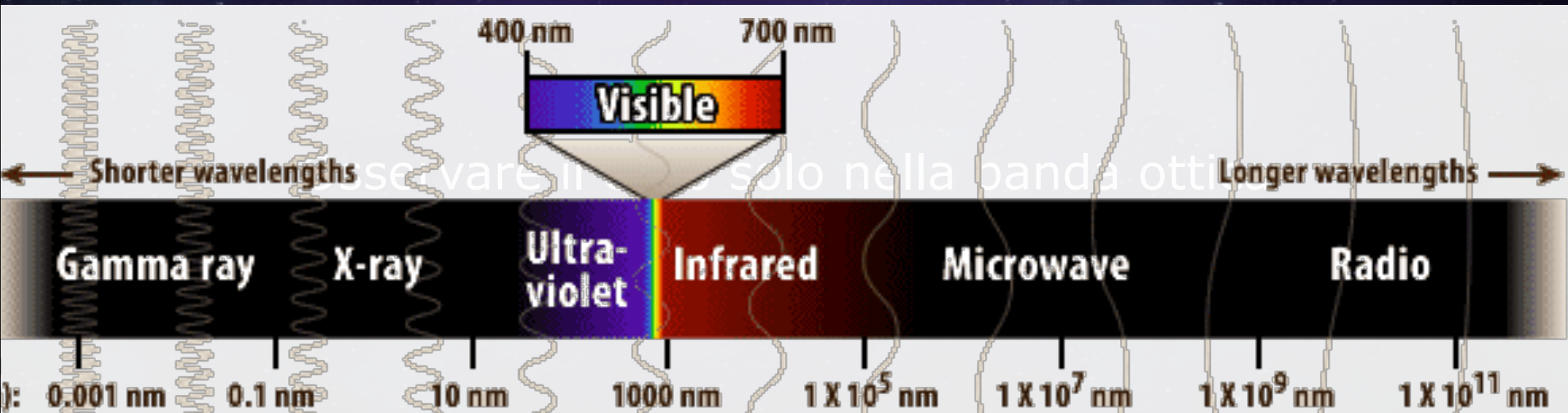
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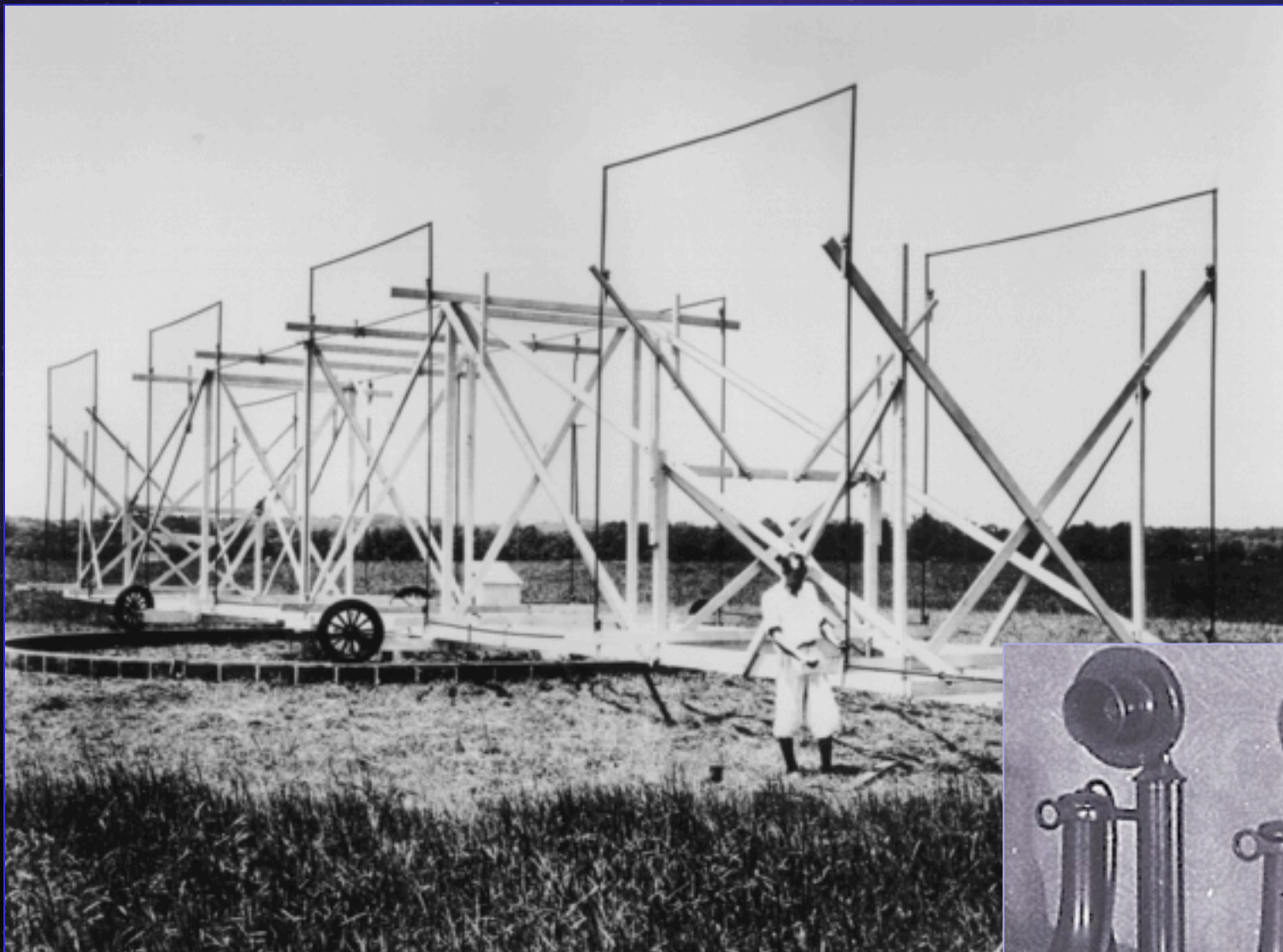
Lo spettro elettromagnetico



L'Astronomia multi-frequenza



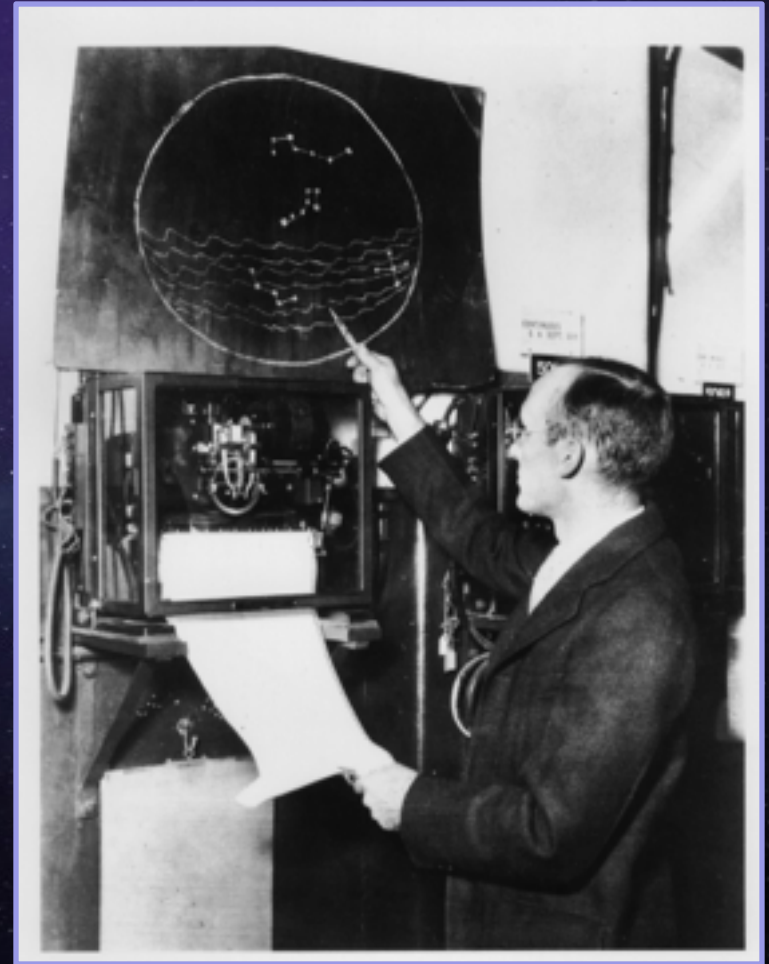
La Radioastronomia



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

MON. MAY 1, 1933

NEW YORK, MON., MAY 1, 1933

NEW YORK, MON., MAY 1, 1933

THE PRICE IS 10 CENTS

NEW RADIO WAVES TRACED TO CENTRE OF THE MILKY WAY

Washington, May 1.—(Special to The Times.)—A group of scientists led by Dr. H. J. van den Hul, of the Radio Astronomy Laboratory at the University of Michigan, have announced today that they have traced the source of a group of radio waves to the center of the Milky Way galaxy.

DISCUSSION IS UNDERWAY

Discussed and Tabled for When They Can Be Identified as From Earth's Galaxy

ITS INTENSITY IS LOW

May Be Source of Radio Waves in Galaxy, Scientists Say

RECAPTURE RAPIDLY MADE

Retrospective Under a Far-Reaching Plan

RAIL PROGRAM WIDENED

Features of Railroad Bill

PRESIDENT TELLS OF GAINS

Chamber of Commerce Is Asked to Cooperate on Three Points

NATIONAL UNITY URGED

Property Held Possible Only if All the Branches of Industry React

BIG NEW INVASION PLANNED BY JAPAN

Large-Scale Invasion That Led to Invasion in Manchuria

CHINA RUMORS AS MORTAL

Foreign Office That Thought of War, 20,000 in Force

BRITISH MUST RECONSIDER

Foreign Office That Thought of War, 20,000 in Force

KIDNAPPERS URGED TO ANSWER PLEAS

New Yorker Wanted to Act as Secret Agent for Return of Kidnapped Child

FRENCH READY AS HOSTAGES

French Ready to Act as Hostages for Return of Kidnapped Child

WANTS PART OF DEBT AND IN

Texas, N. C. and Massachusetts

POLICE OFFICERS

Police Officers in New York

LEGAL BARRIERS FOR MILLER

By Stop in Public Trial

FARM BILL CLAUSE BLOCKS AGREEMENT

Confusion, Much Said as to Effect of Text of Production Section

PEEK BLAMED FOR THIS

Wreck Equipment, Water in Reservoir's Cause to Be Administration

BRITISH DEMANDING TARIFF SAFEGUARDS

ITALIANS NOW BACK BRITISH ARMS PLAN

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ROOSEVELT ASKS PAY RISE FOR WORKERS;

PROMISES TO HELP BUSINESS END CHAOS;

HE SENDS RAILROAD BILL TO CONGRESS

Washington, May 1.—(Special to The Times.)—President Roosevelt today asked Congress to raise the minimum wage for workers in the United States to 25 cents an hour, and promised to help business end chaos by sending a railroad bill to Congress.

CHAMBER OF COMMERCE ASKED TO COOPERATE ON THREE POINTS

Washington, May 1.—(Special to The Times.)—President Roosevelt today asked the Chamber of Commerce to cooperate on three points: to help end chaos in business, to help end chaos in business, and to help end chaos in business.

NATIONAL UNITY URGED

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GOVERNMENT ASKED TO RECONSIDER

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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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NEW YORK, FRIDAY, FEBRUARY 12, 2016

\$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:

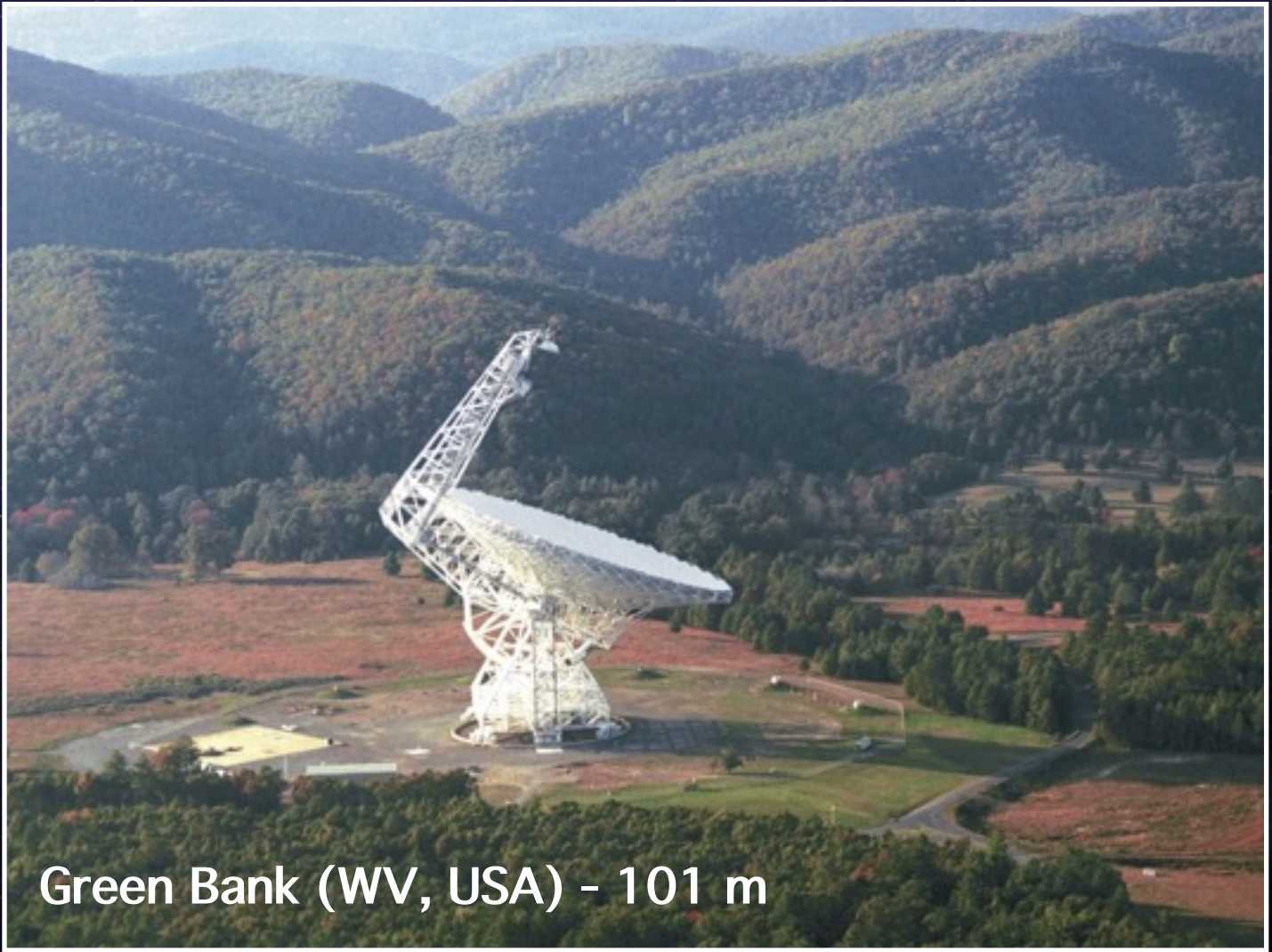




Effelsberg (DE) - 100 m



Jodrell Bank (UK) - 76 m



Green Bank (WV, USA) - 101 m



Arecibo (PR, USA) - 300 m

ATCA (NSW, Australia)



WSRT (NL)

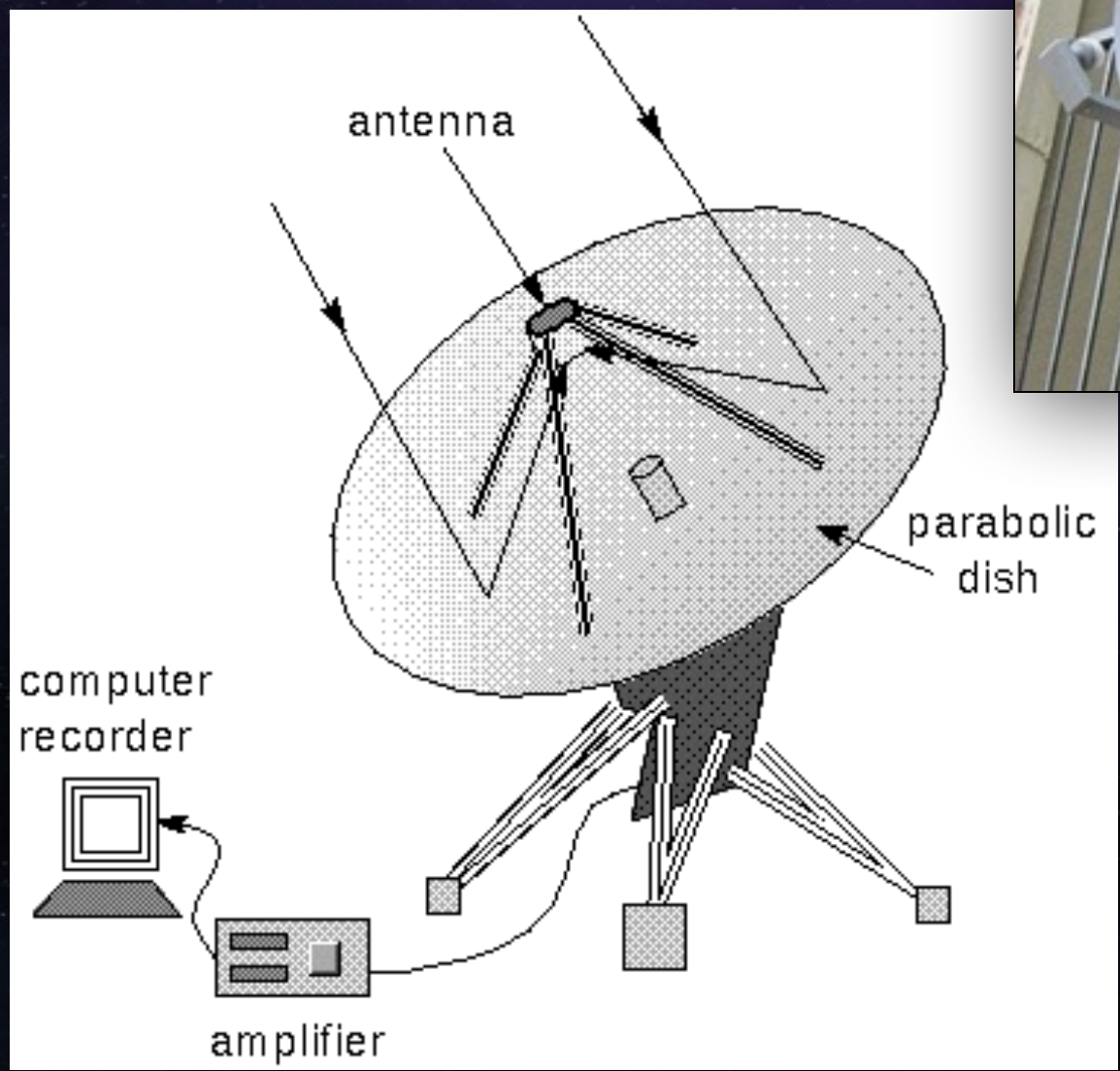


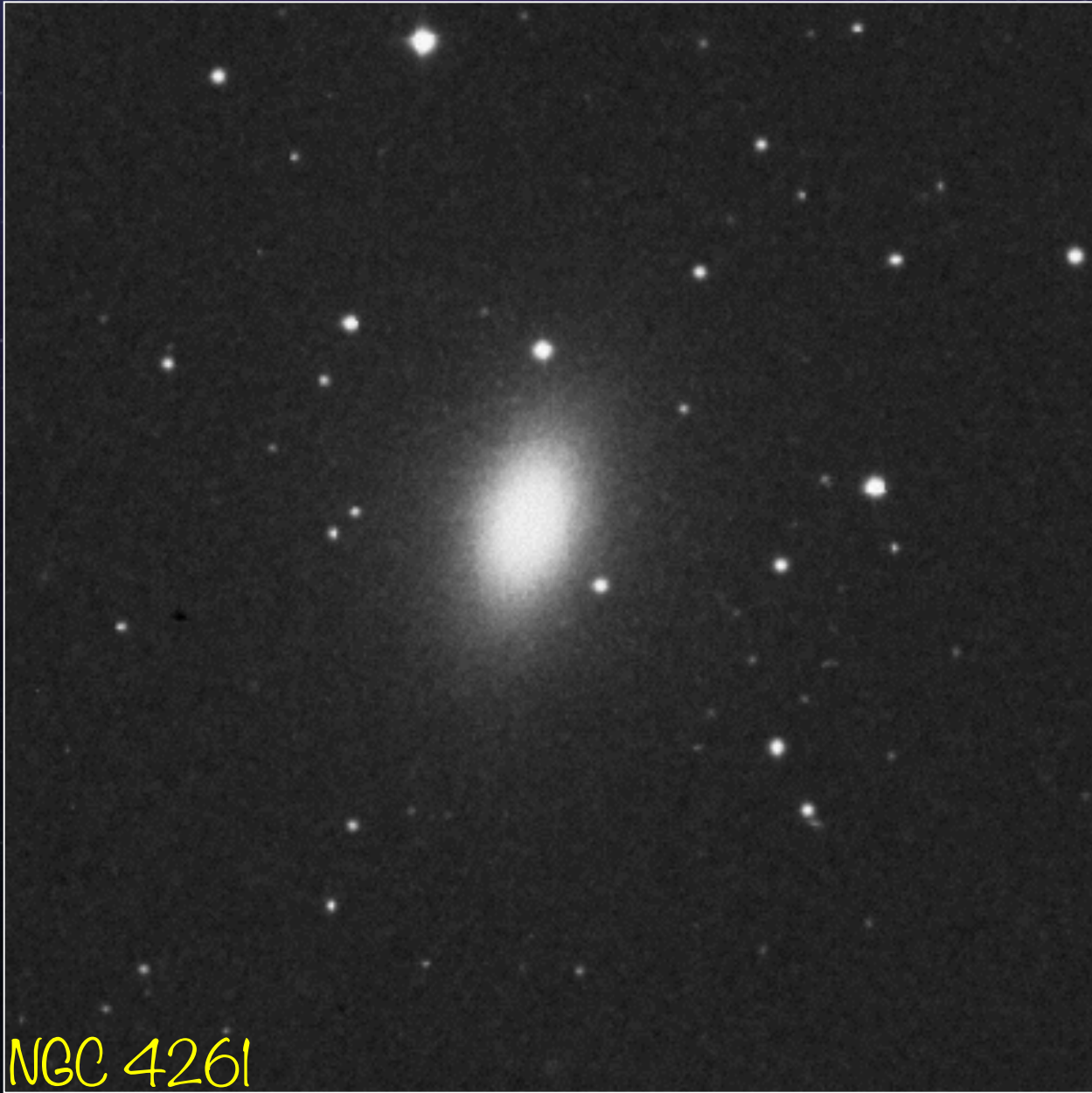
VLA (NM, USA)



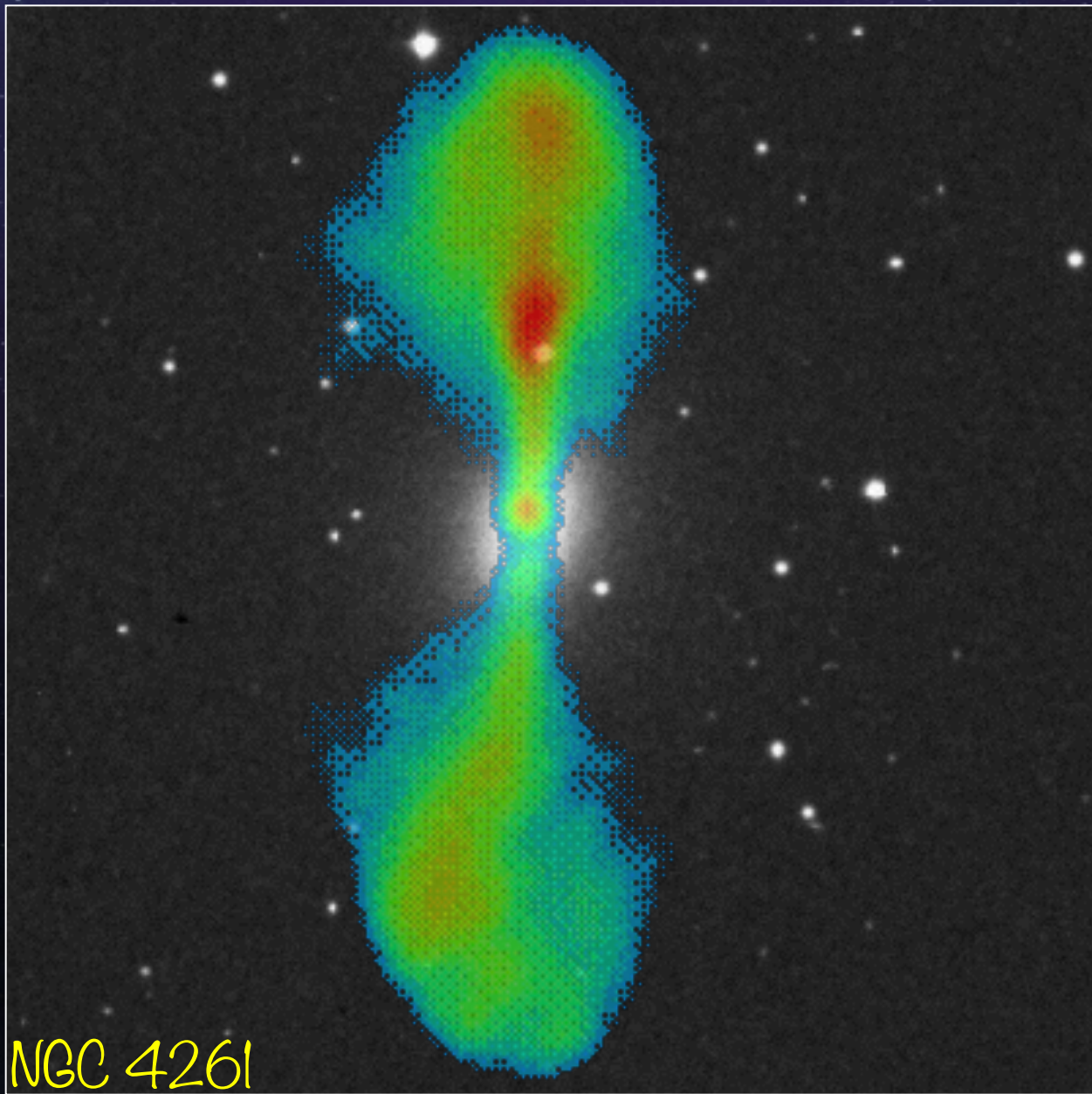
I radioastronomi non ascoltano le onde radio!







NGC 4261



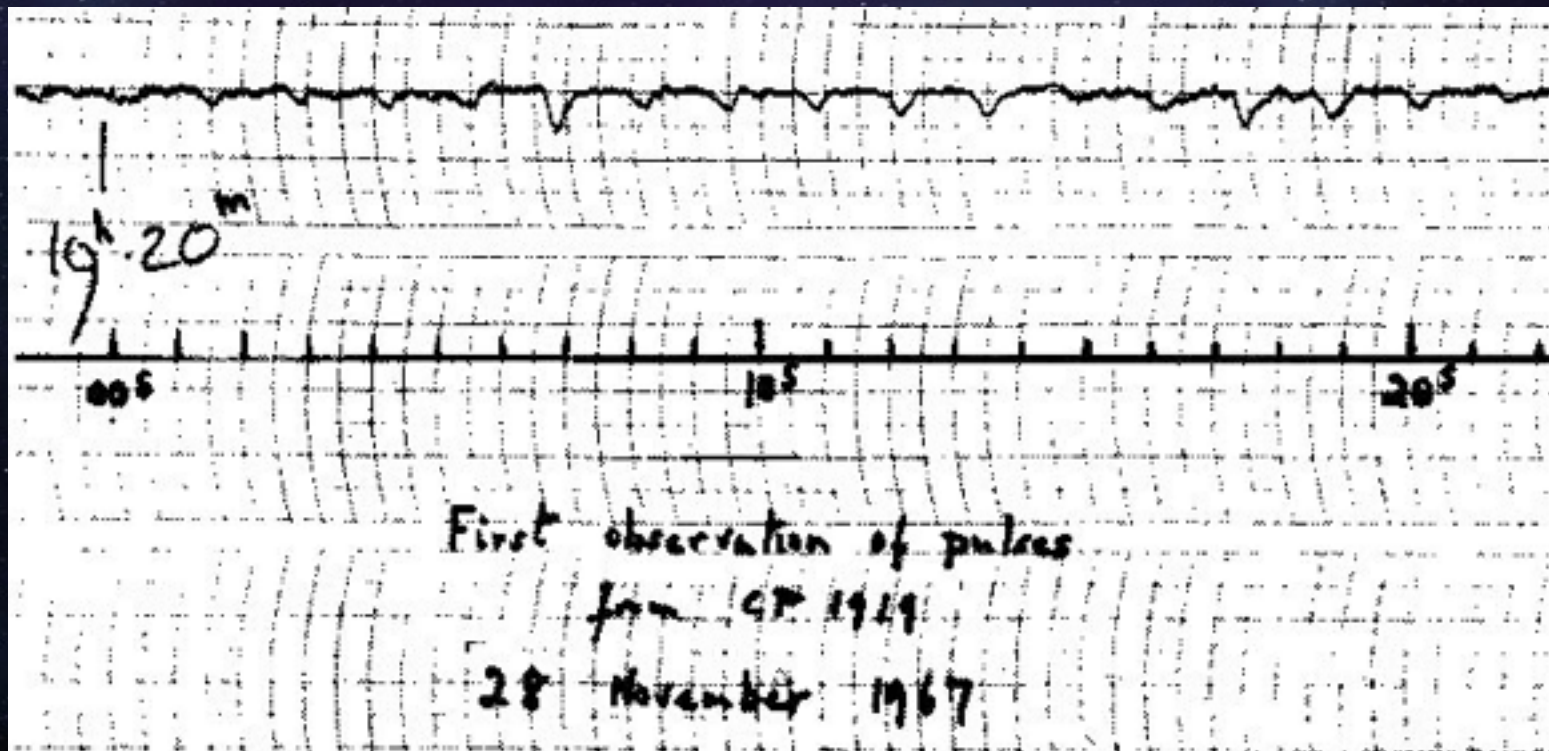
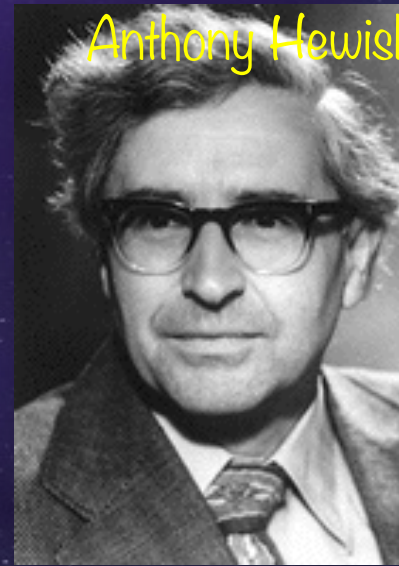
NGC 4261

Le Pulsar

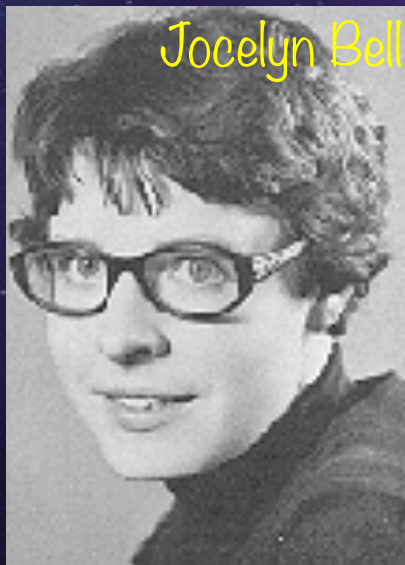
Jocelyn Bell



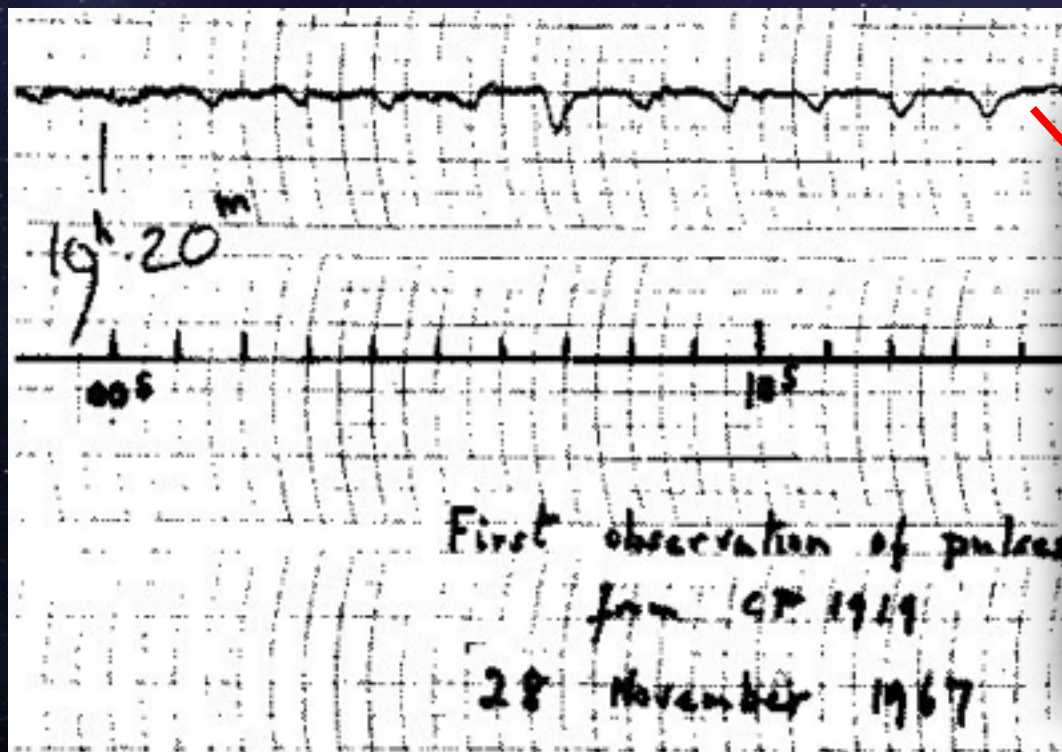
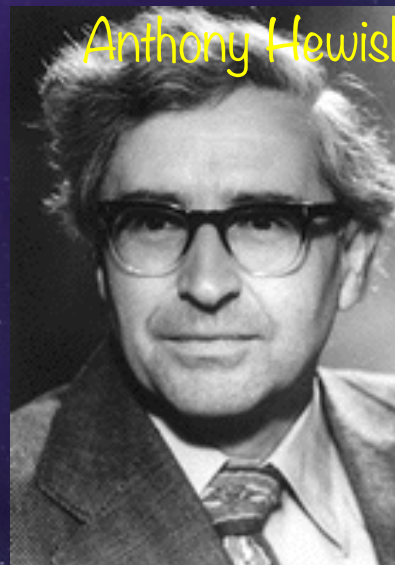
Anthony Hewish



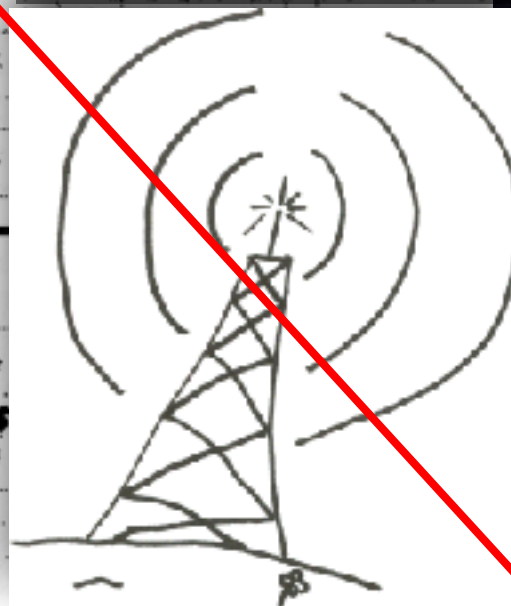
Jocelyn Bell



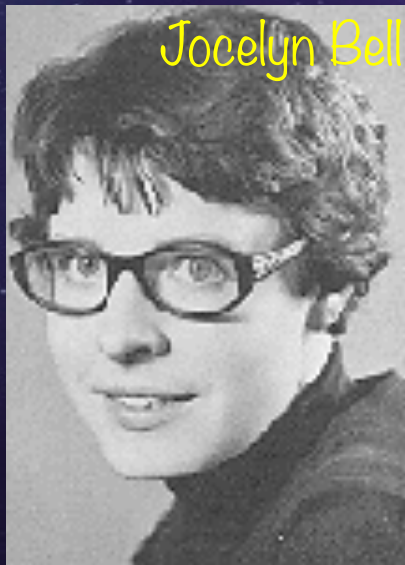
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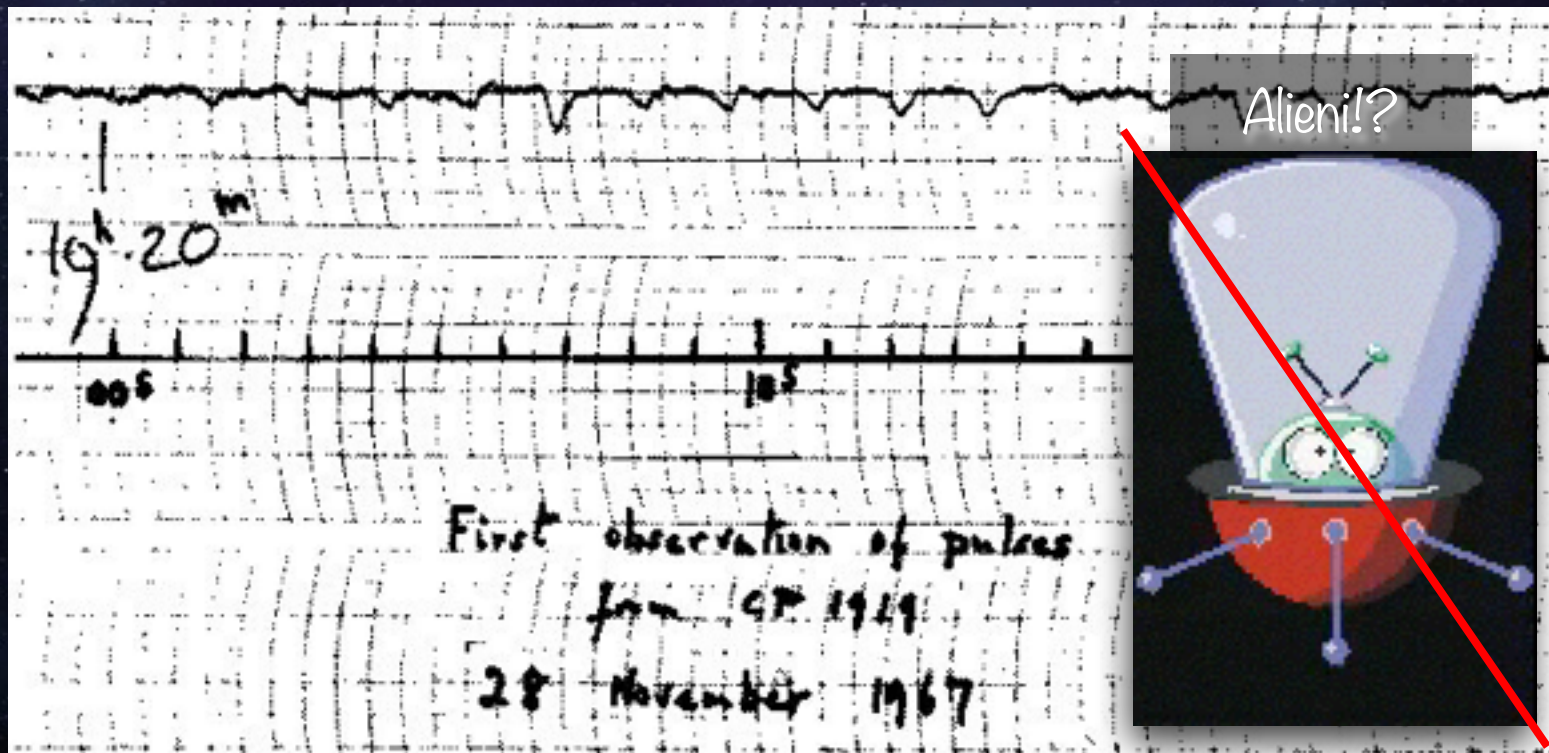
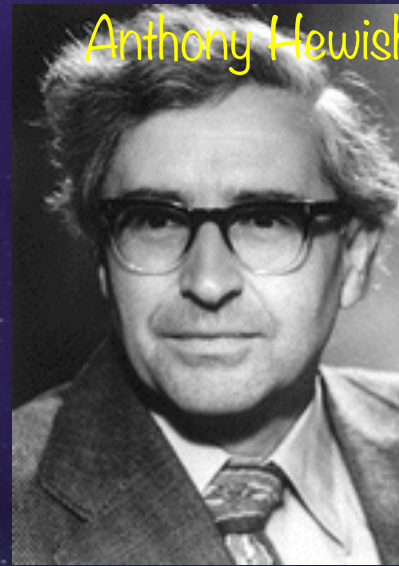
Interferenze terrestri?



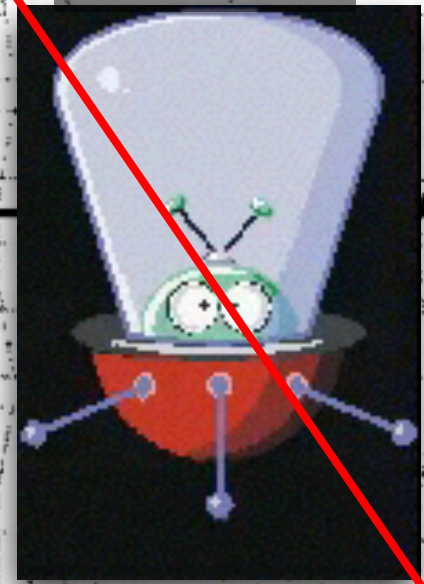
Jocelyn Bell



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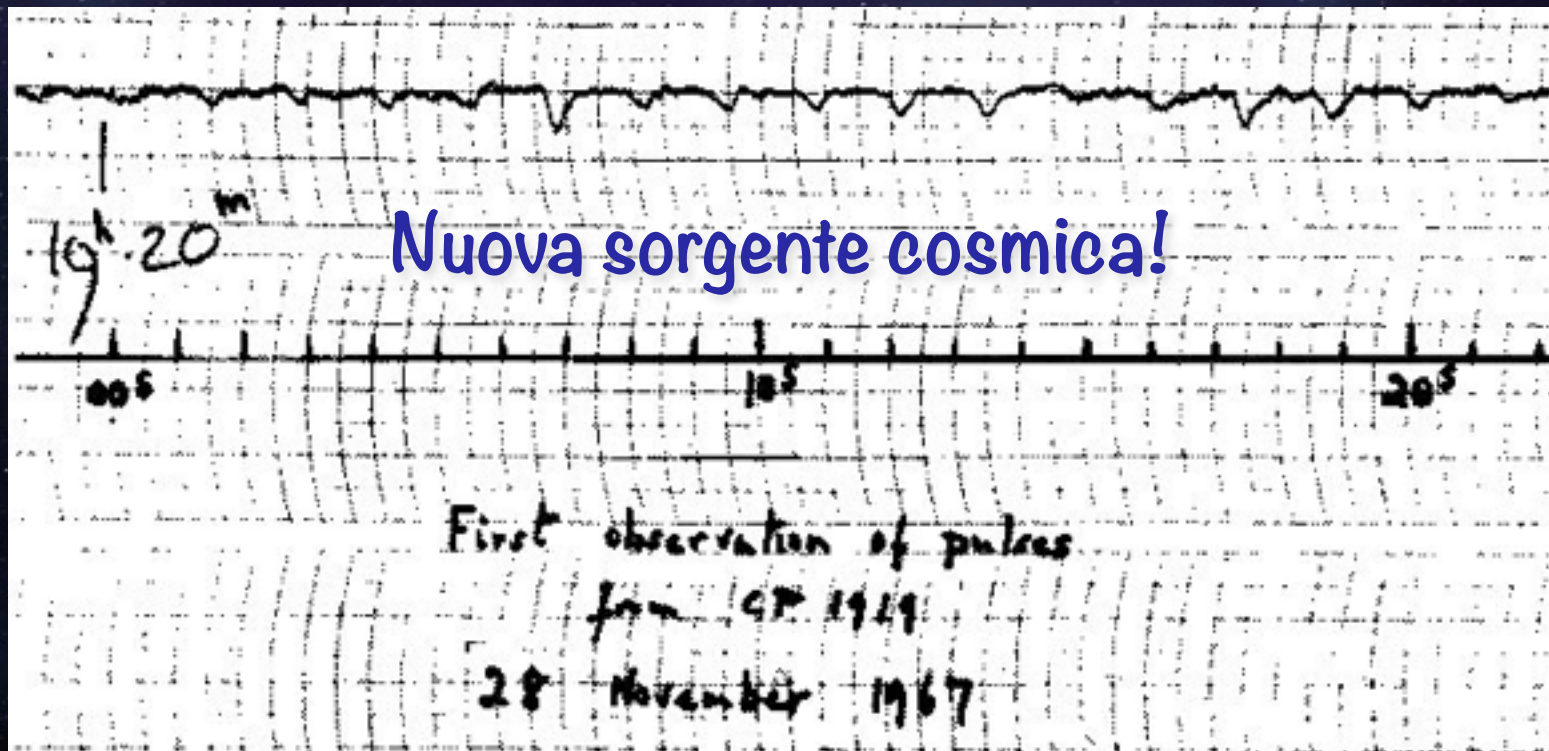
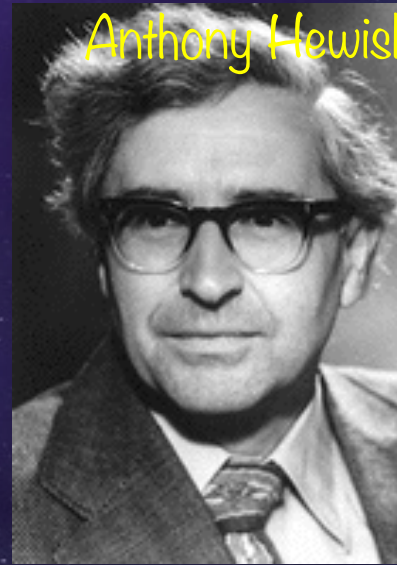
Alieni!?

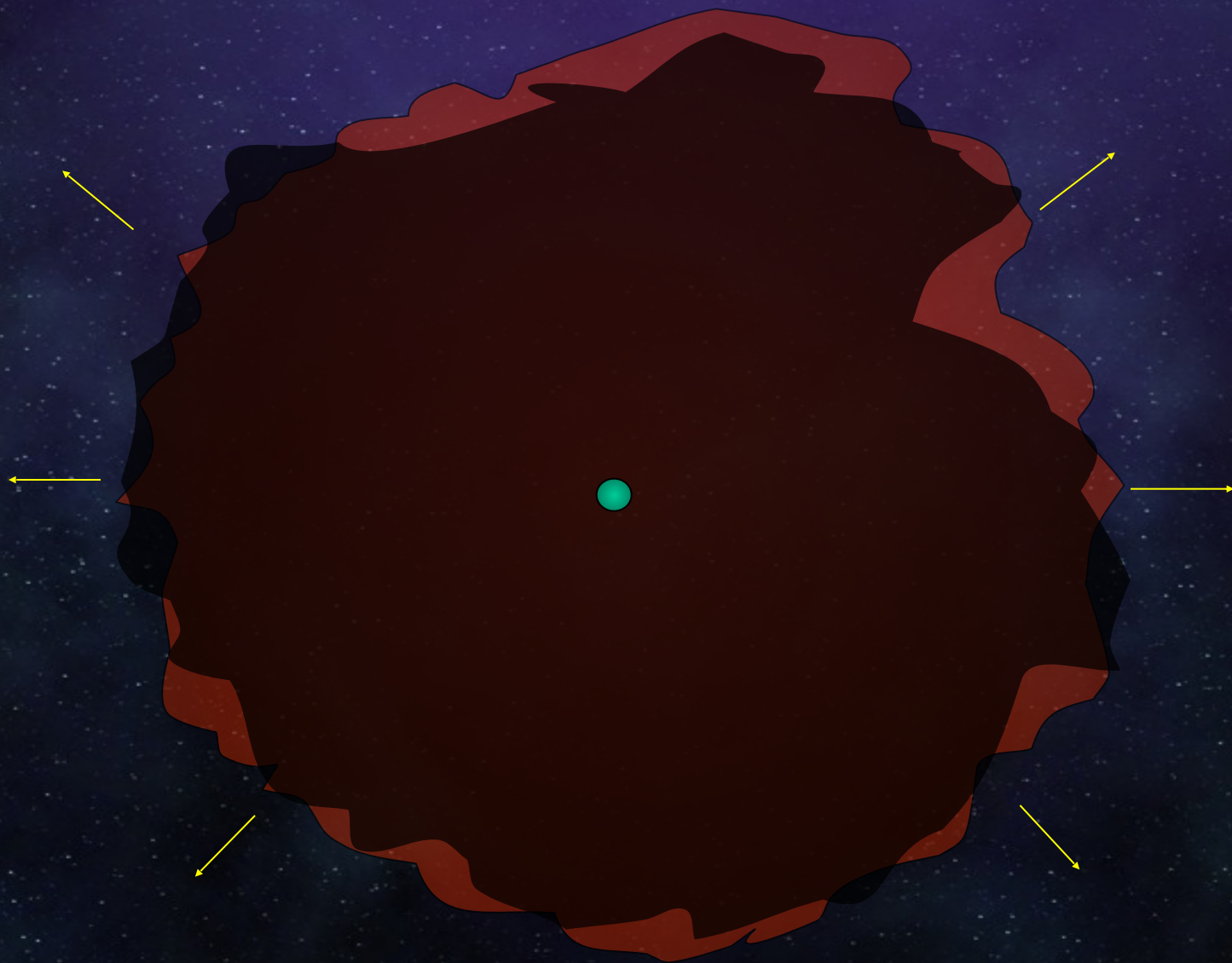


Jocelyn Bell



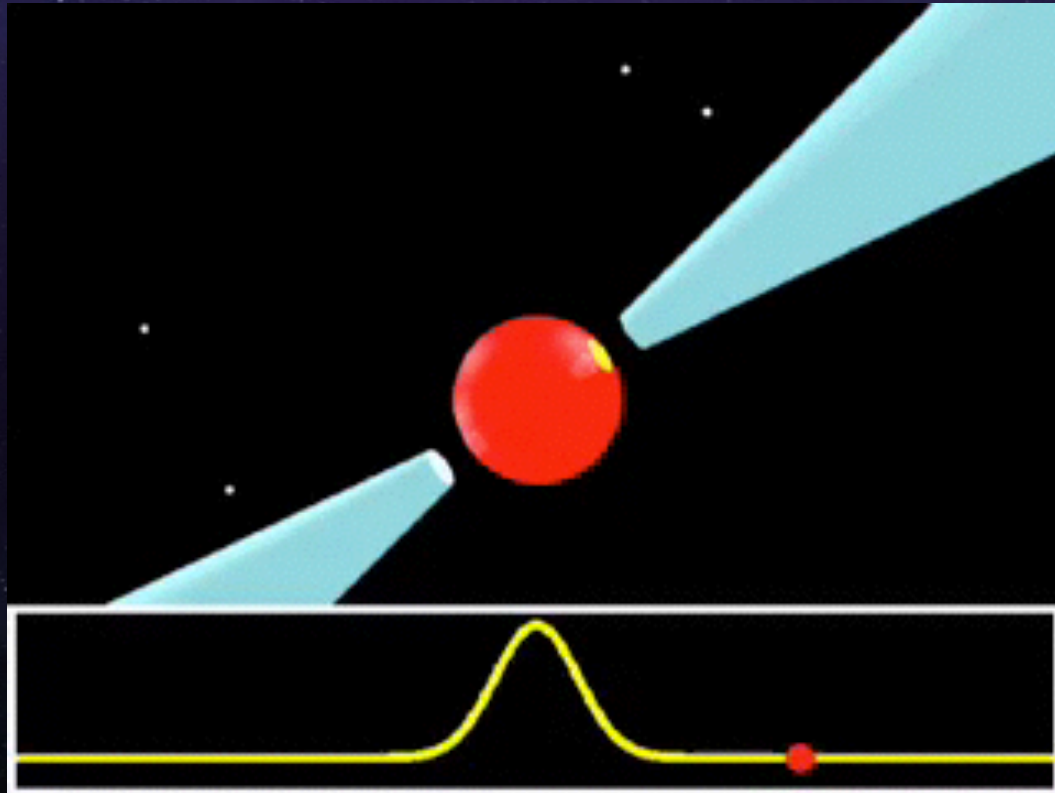
Anthony Hewish





Rimane una “stella di neutroni”



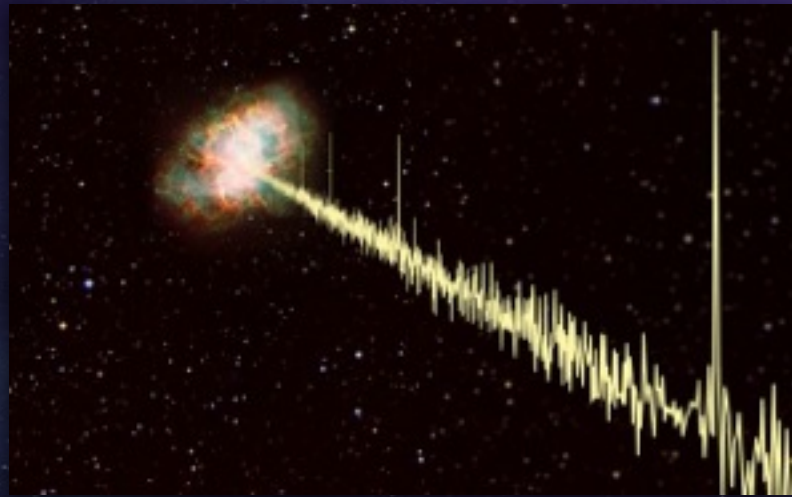


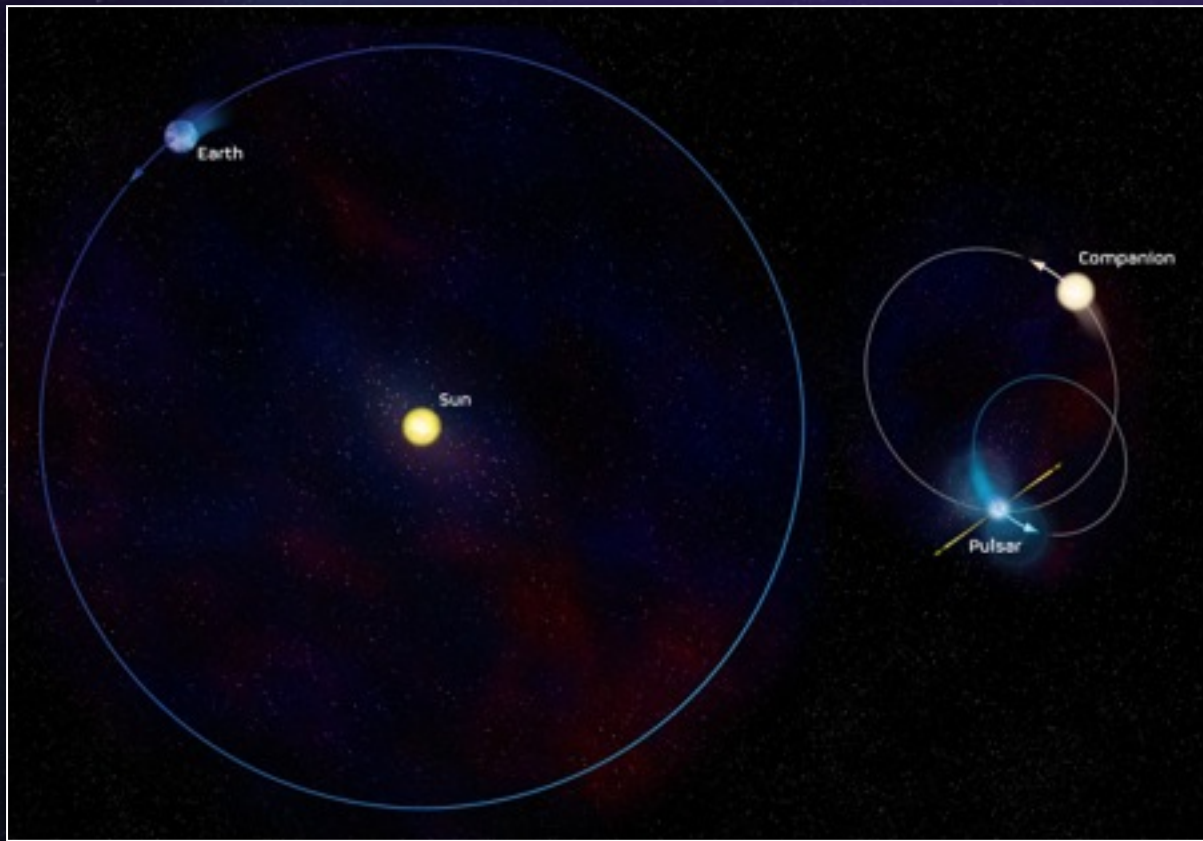
Dal 1967 ad oggi scoperte più di 2500 pulsar

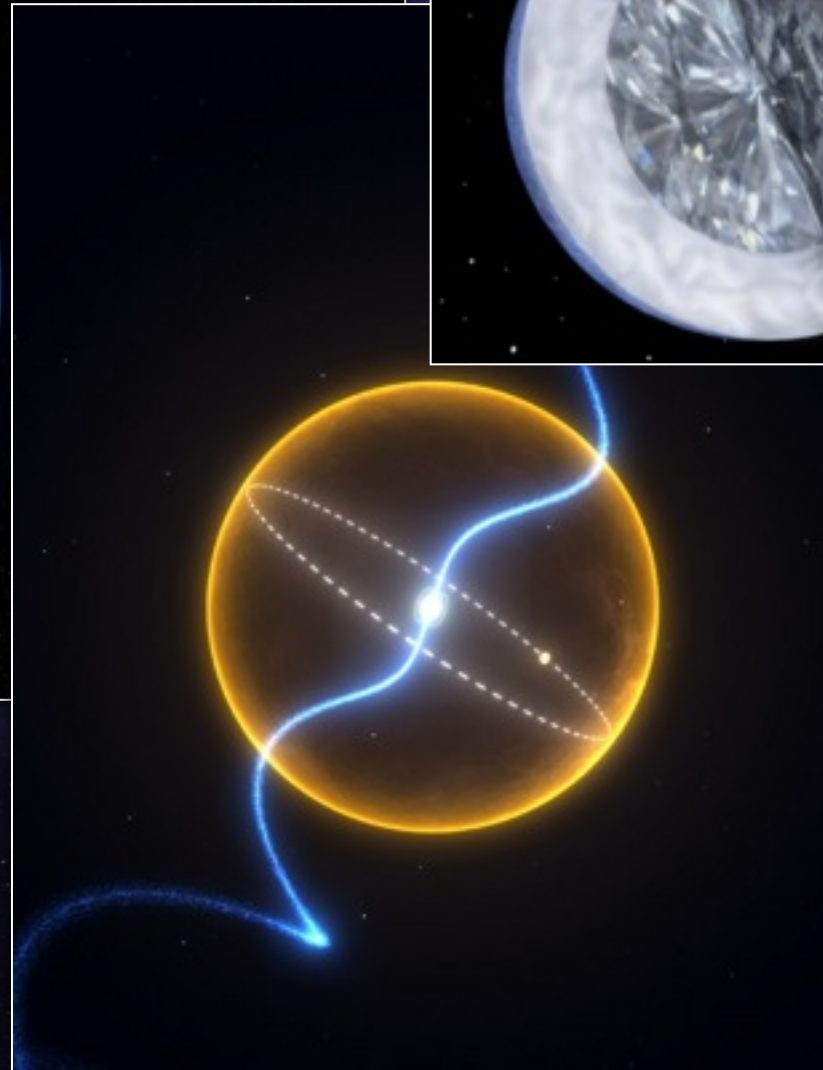
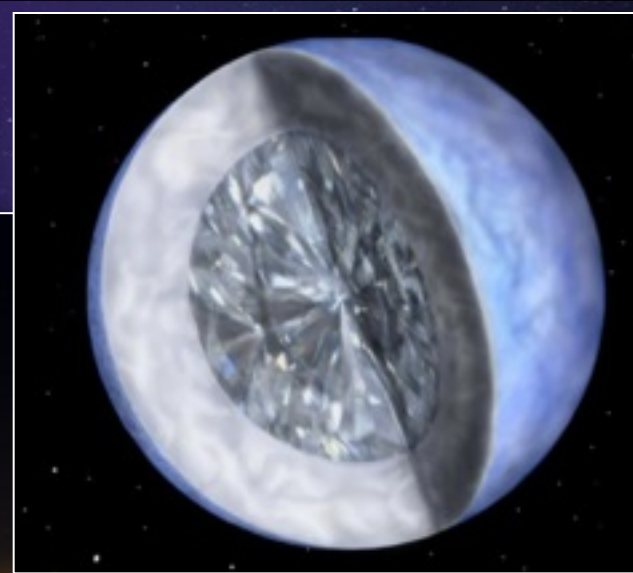
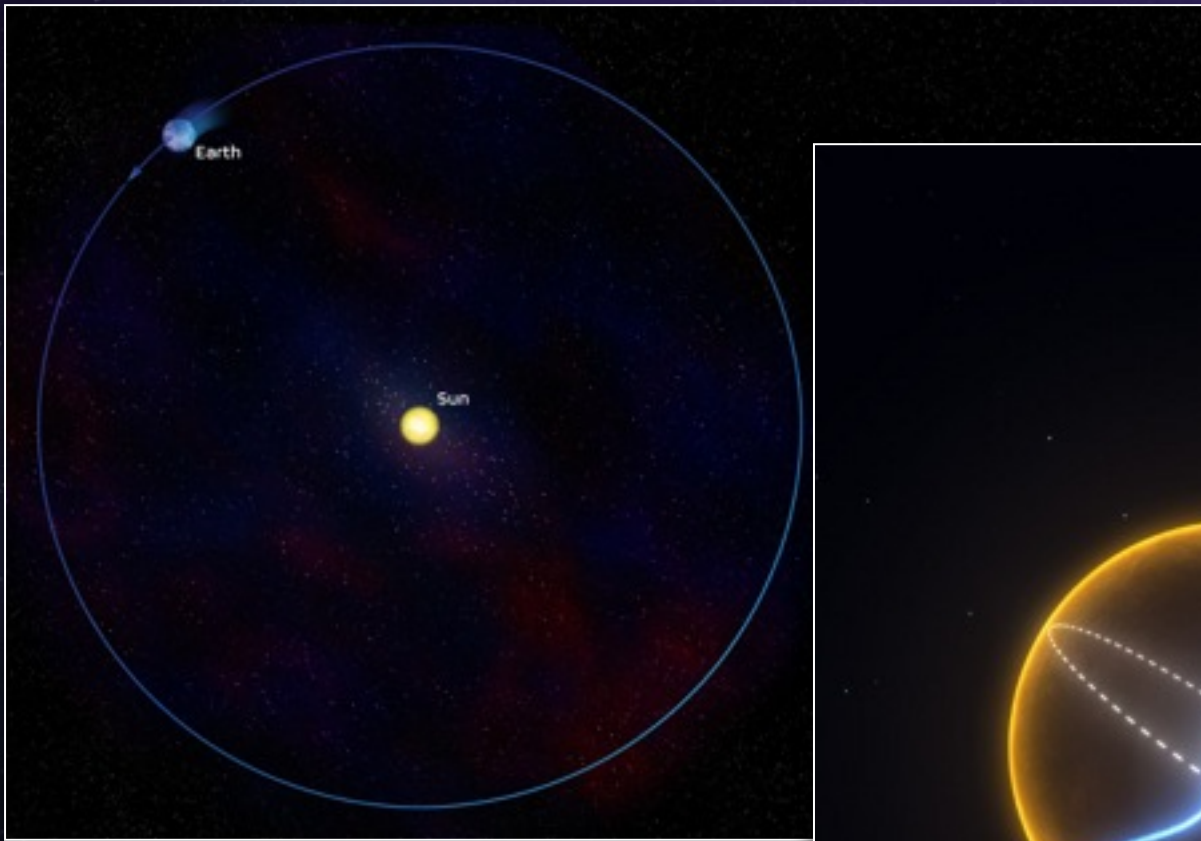


A zodiac wheel with constellation figures and a central clock face. The wheel is divided into 12 segments, each representing a zodiac sign. The central clock face has numbers 1 through 12. The background is dark with some glowing orange and purple circles.

$0.00155780652149318686248 \pm 0.00000000000000000000000003 \text{ sec}$



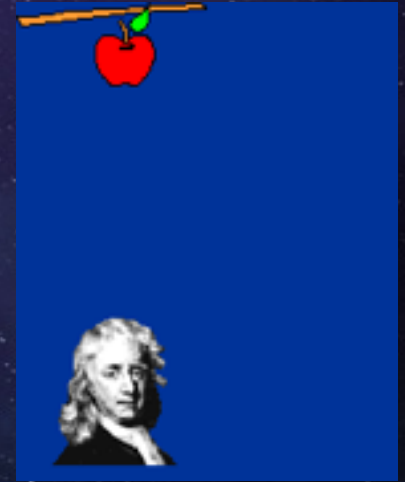




(Pulsar in)
sistemi binari

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



Ecco perché la mela cade sulla terra !

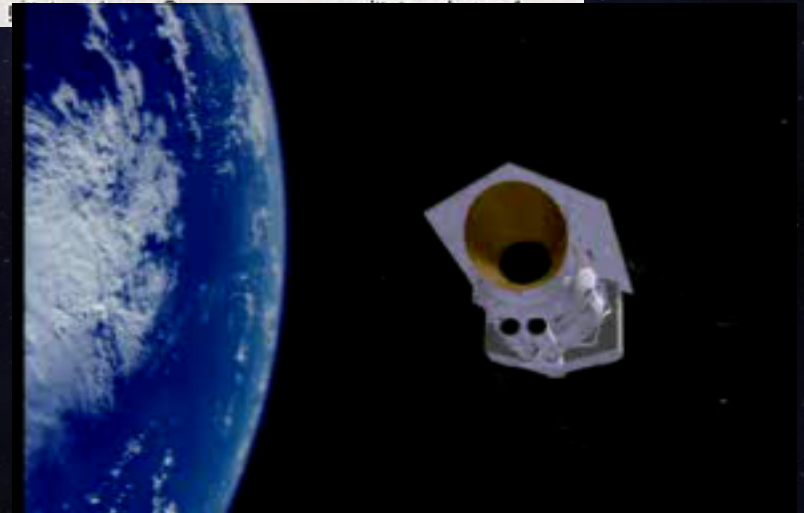
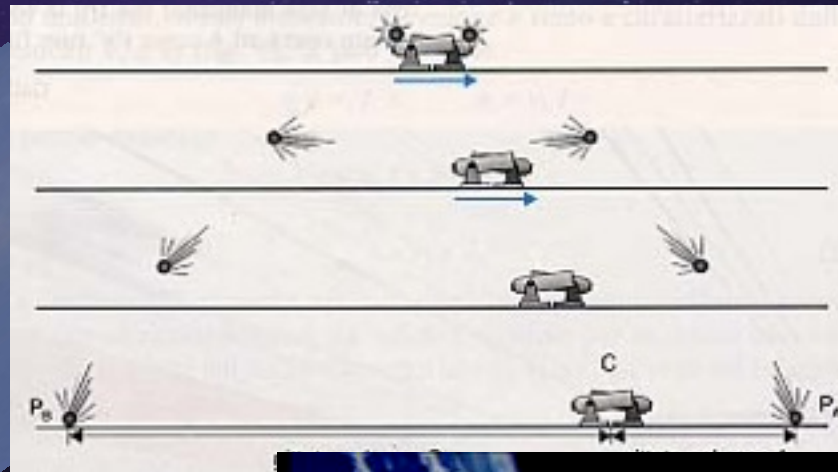
Secondo Newton, una massa M (il Sole) esercita su una massa m (la nostra Terra, posta ad una distanza D dal Sole) una forza data dalla formula:

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

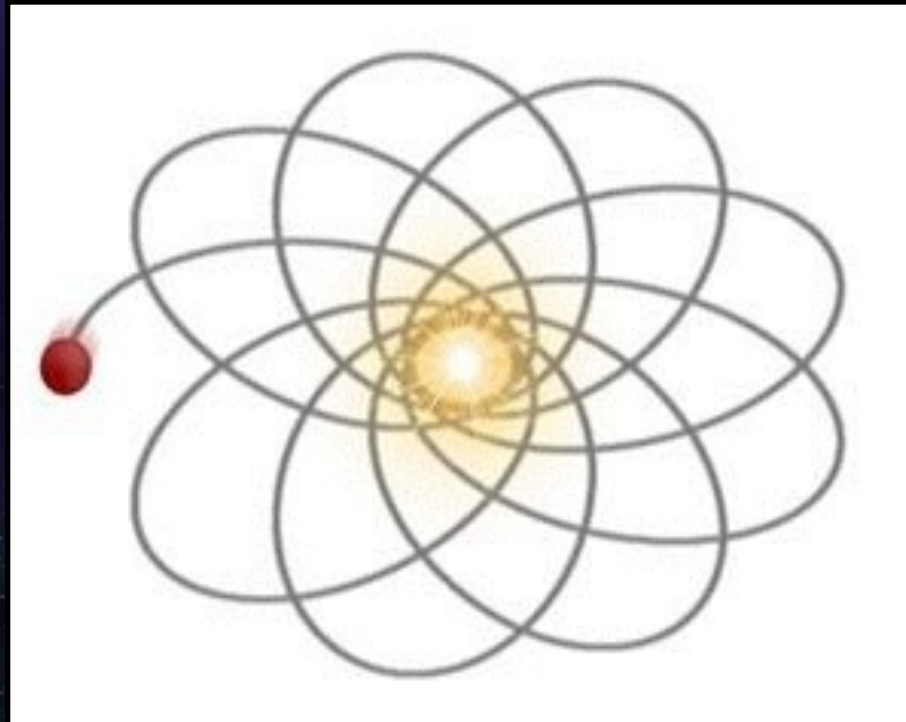


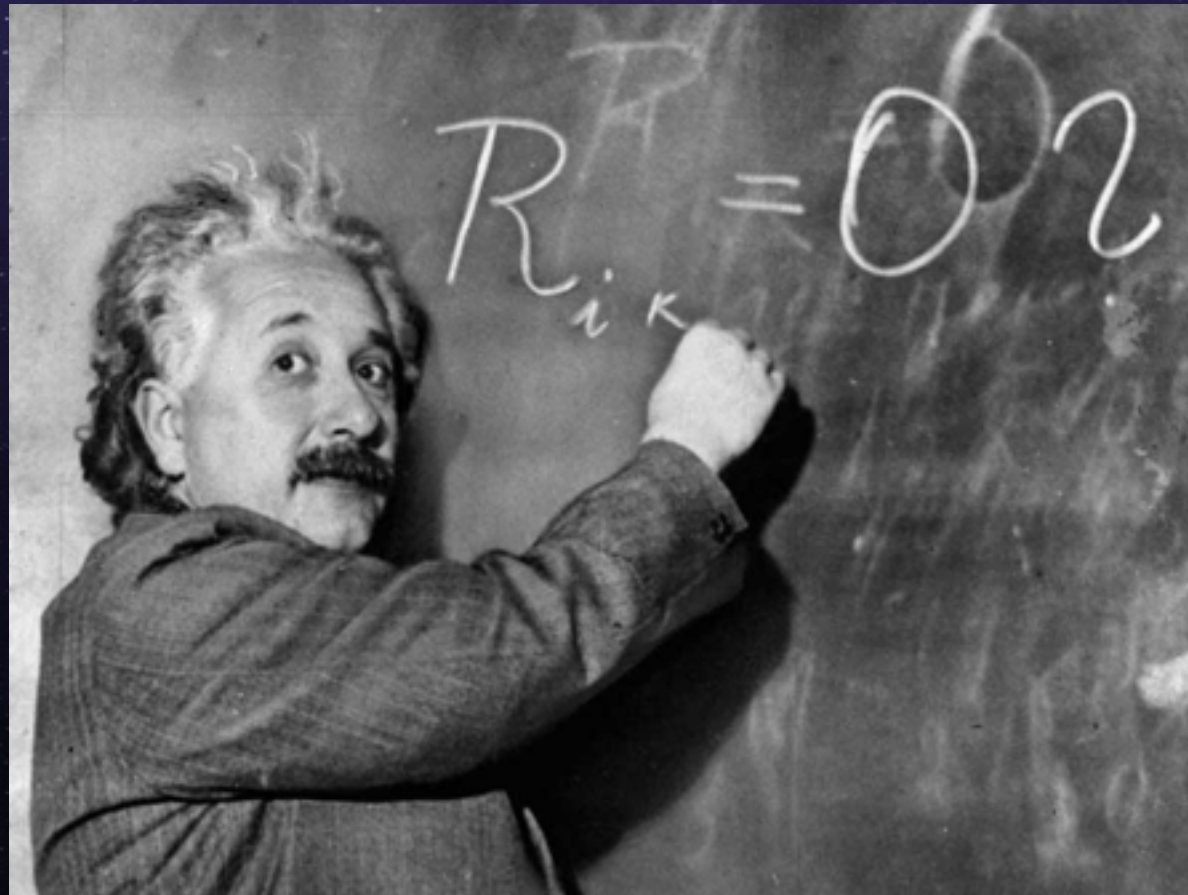
Ecco perché la Terra orbita attorno al Sole!

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



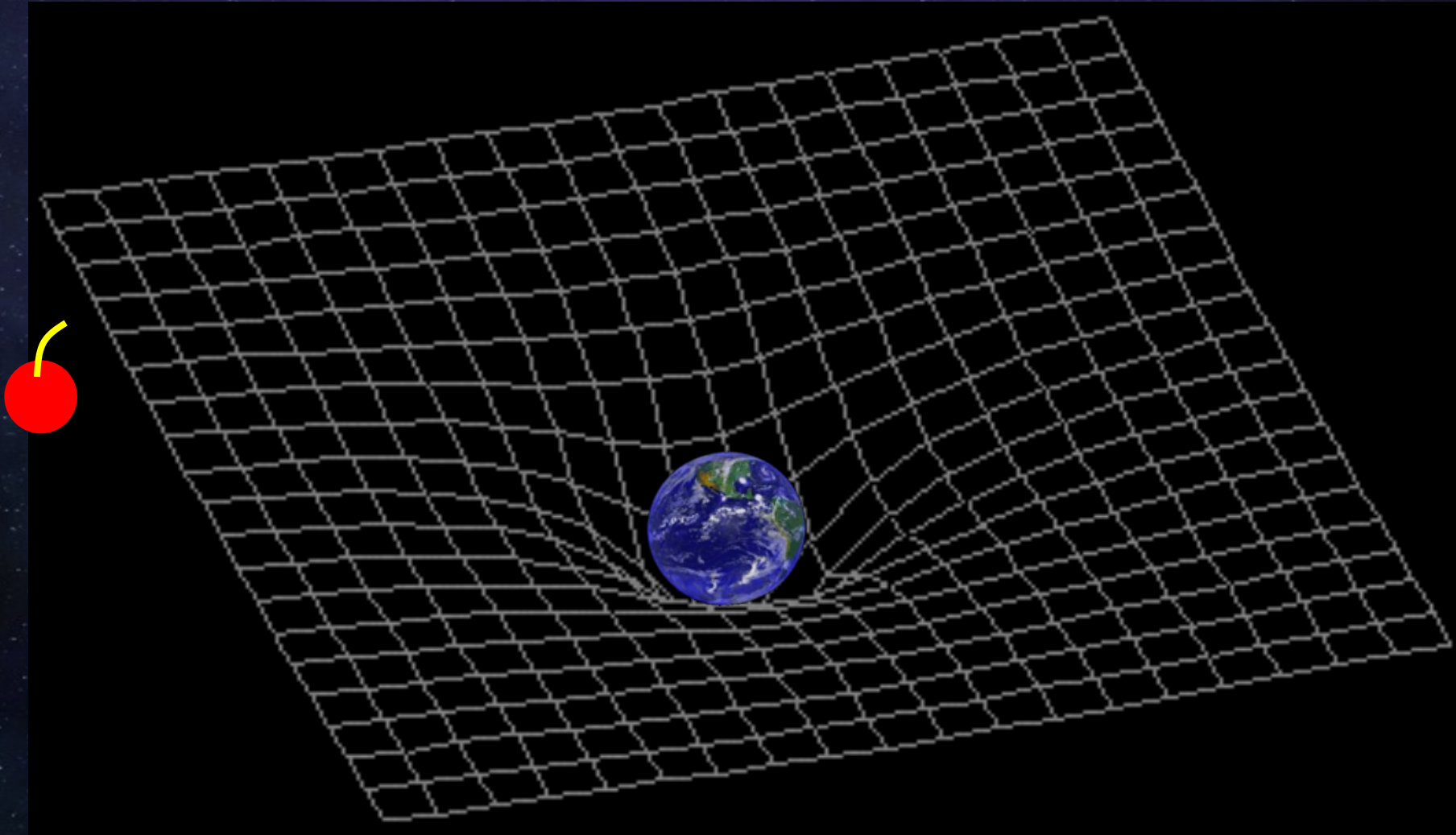
...non tutto torna



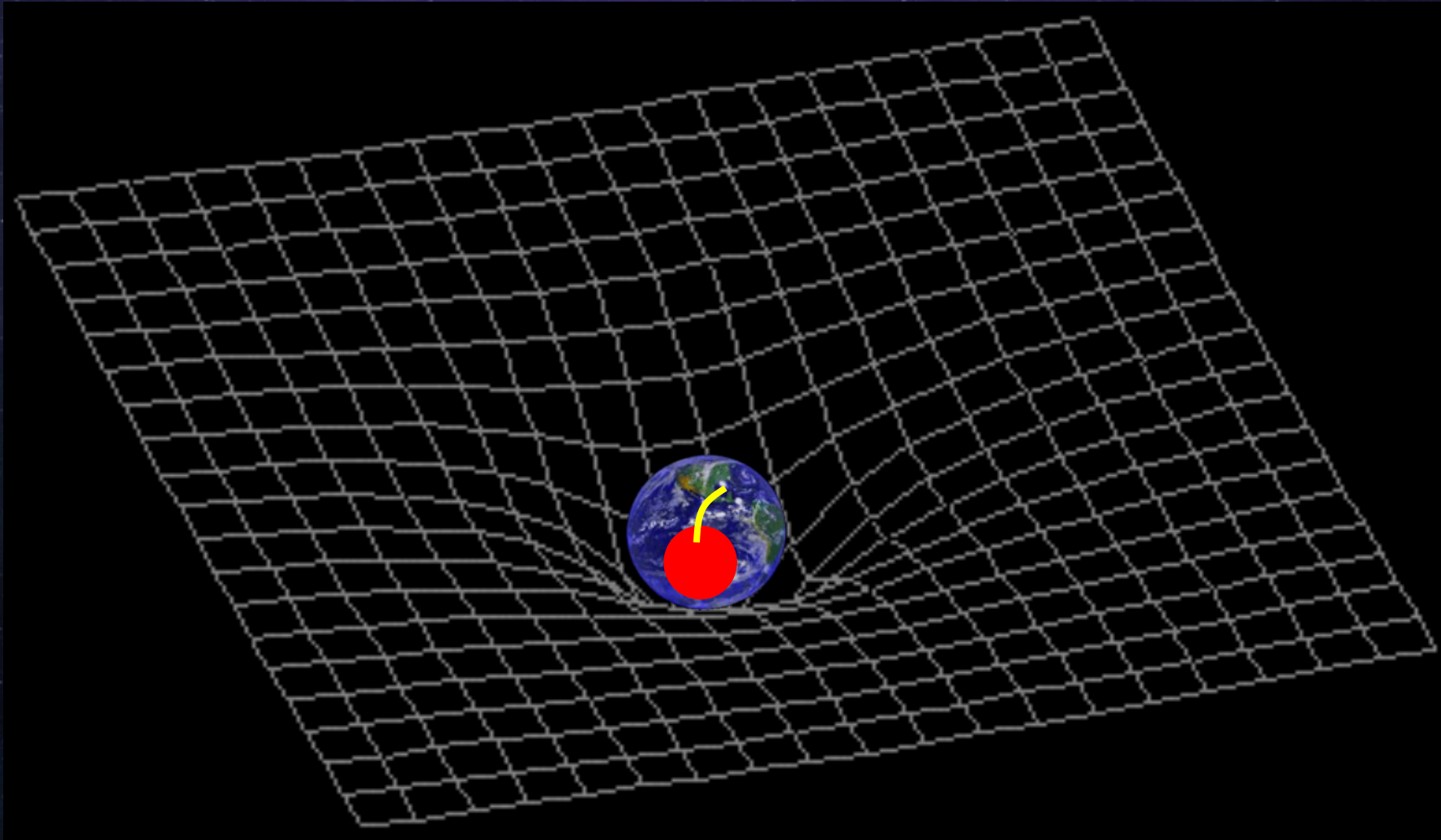


Einstein (1879-1955)

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

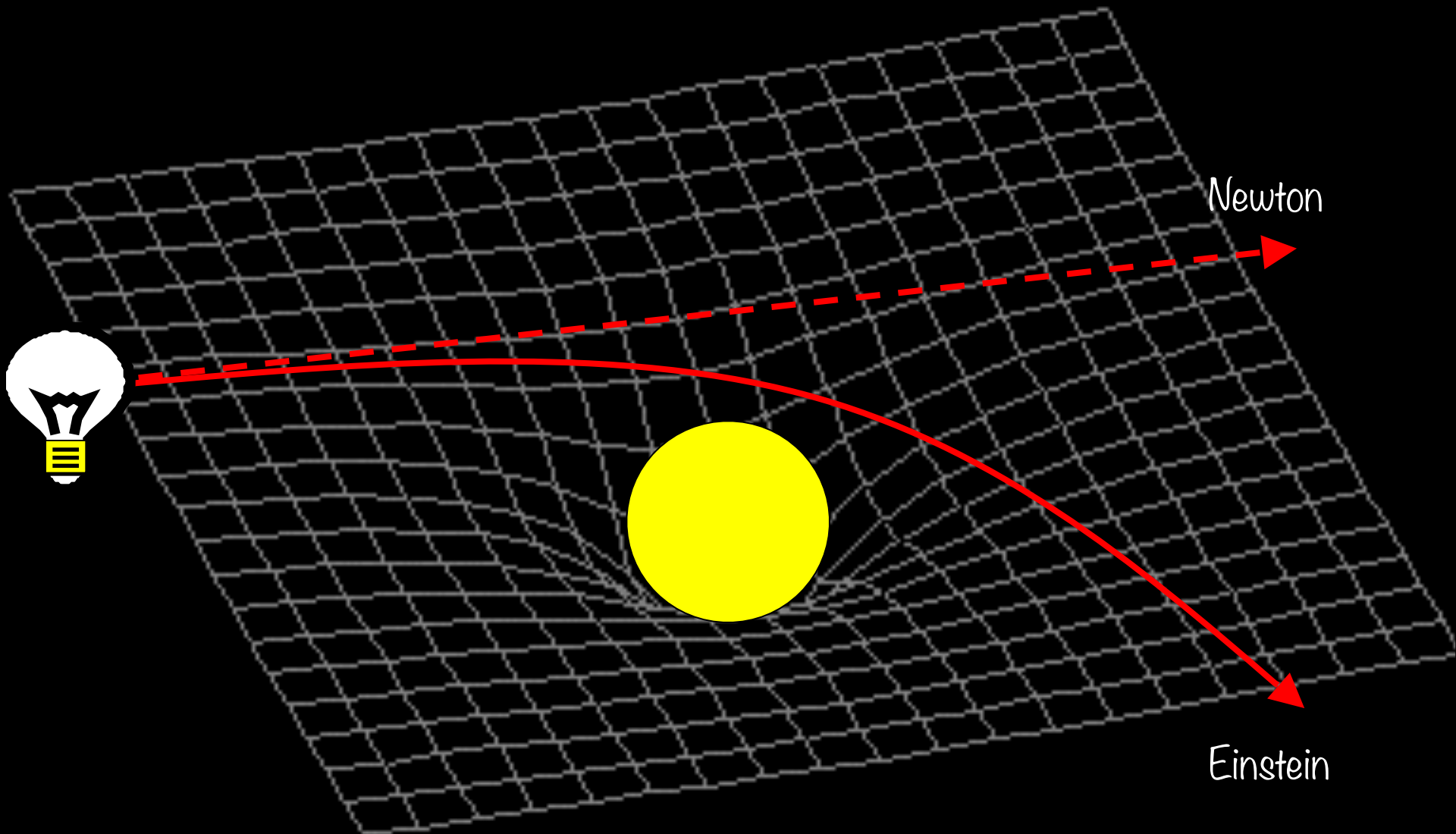


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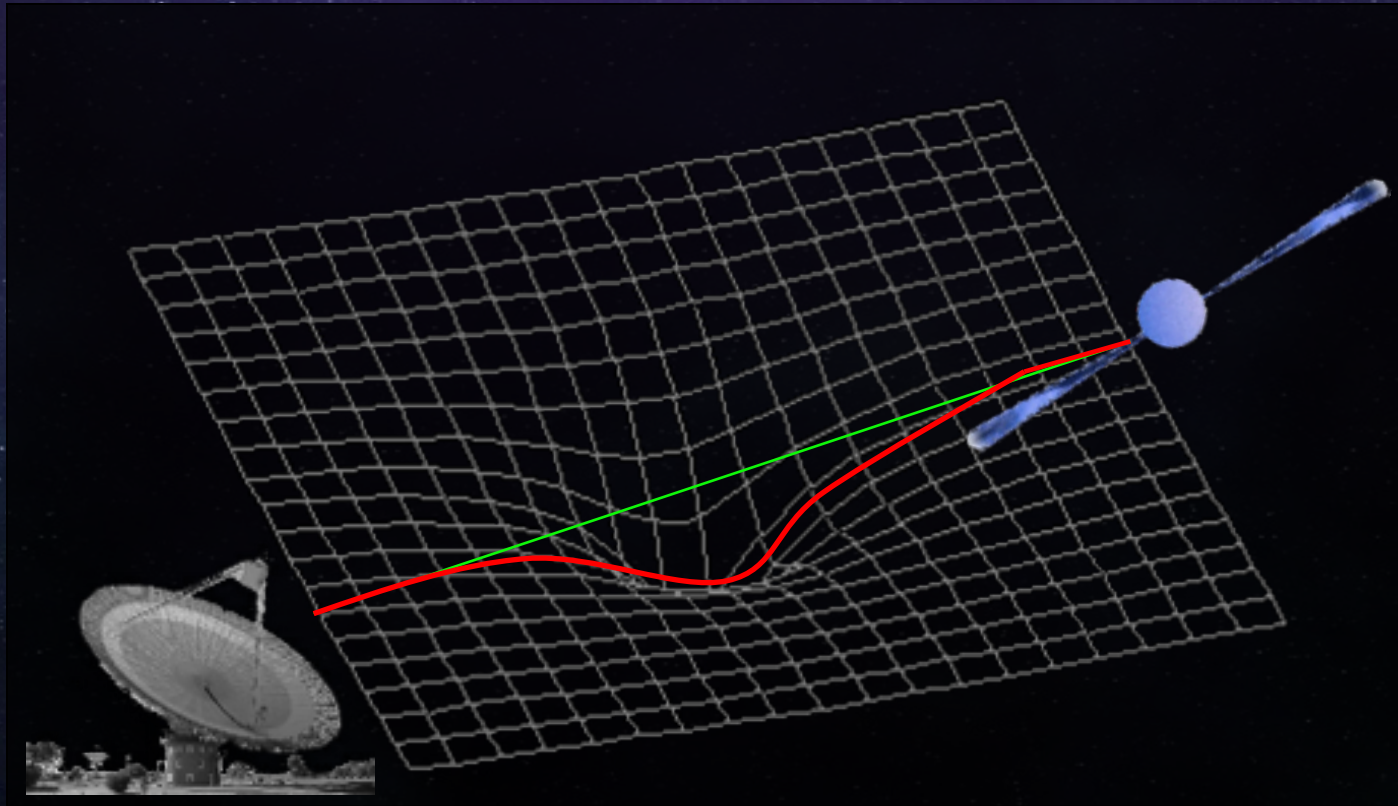


Ecco perché la mela cade sulla terra !

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

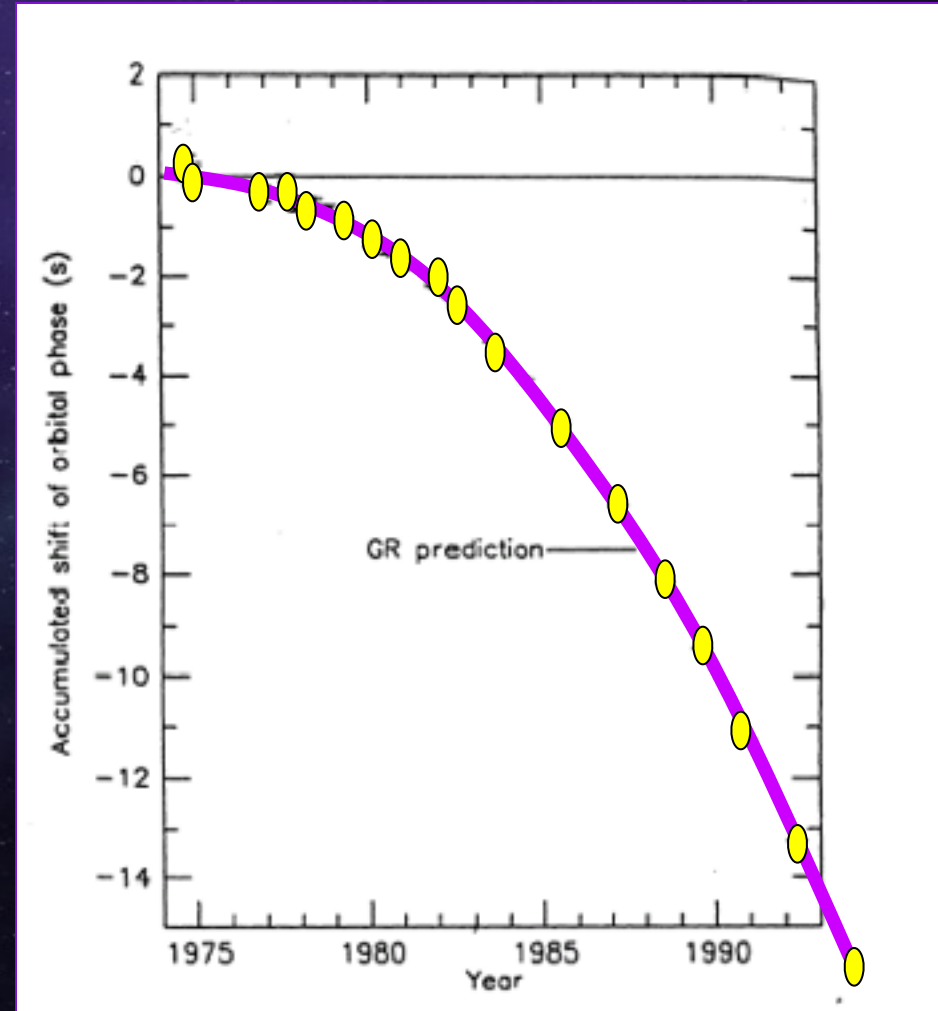


Le Pulsar e Einstein



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 !!!

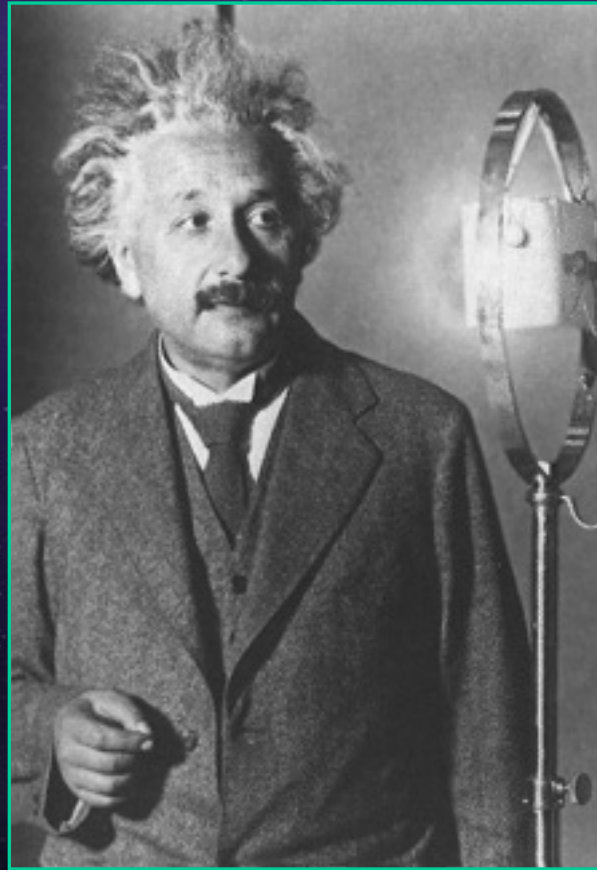
Due pulsar che girano una intorno all'altra in 2.4 ore !!





Misurato in appena 5 giorni di osservazione!!

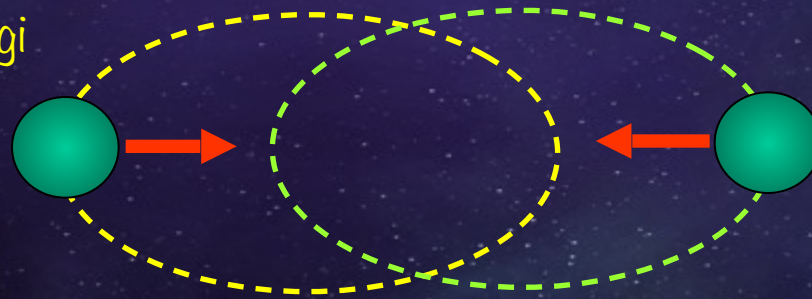
...nella pulsar Doppia abbiamo **DUE** orologi simultaneamente disponibili per studiare la teoria della Relatività Generale



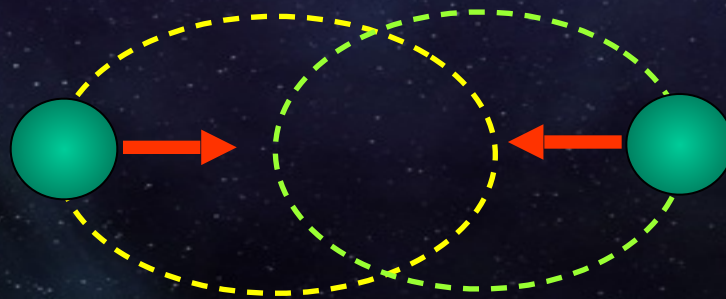
le predizioni di Albert Einstein riflettono il modo di comportarsi della Natura con un errore massimo dello
0.02% !!!!

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

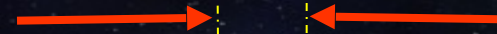
Oggi



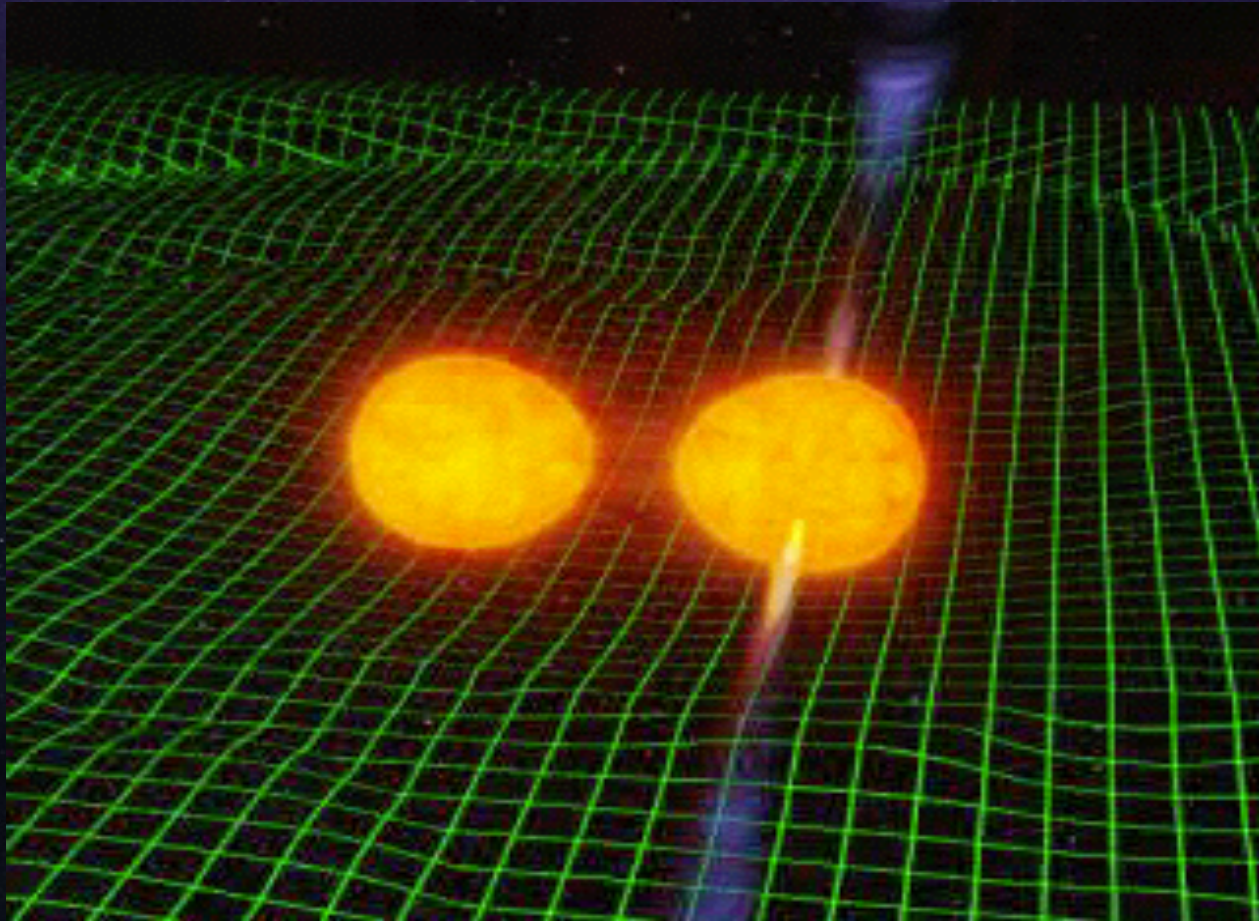
Fra dieci milioni di anni



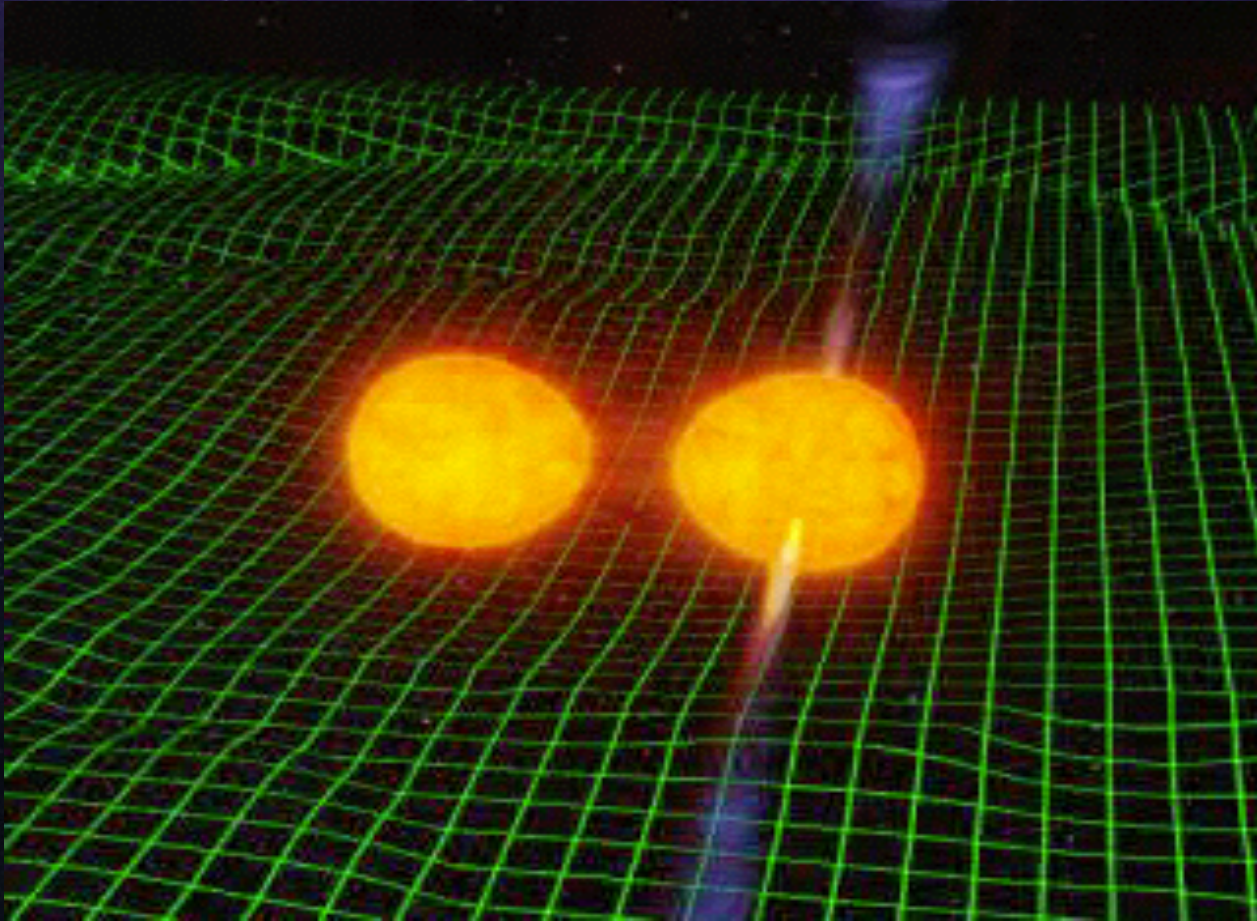
~80 000 km



...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

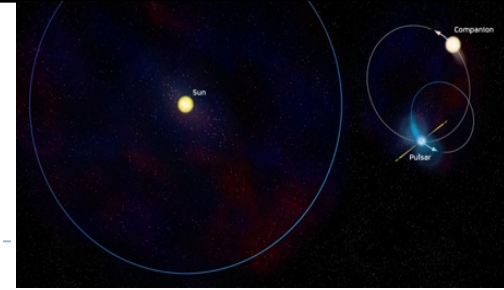


Sergio Poppi



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 !!

