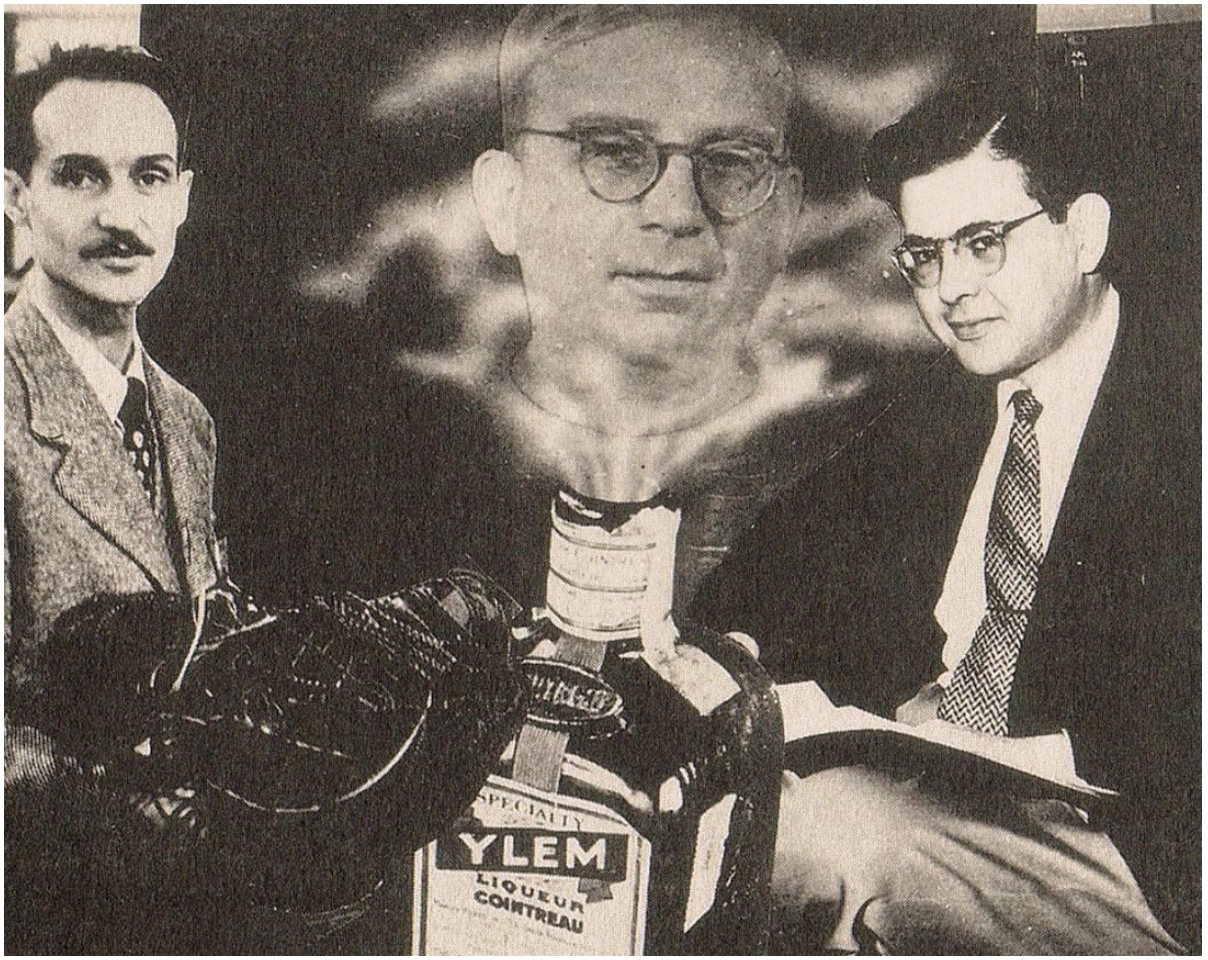
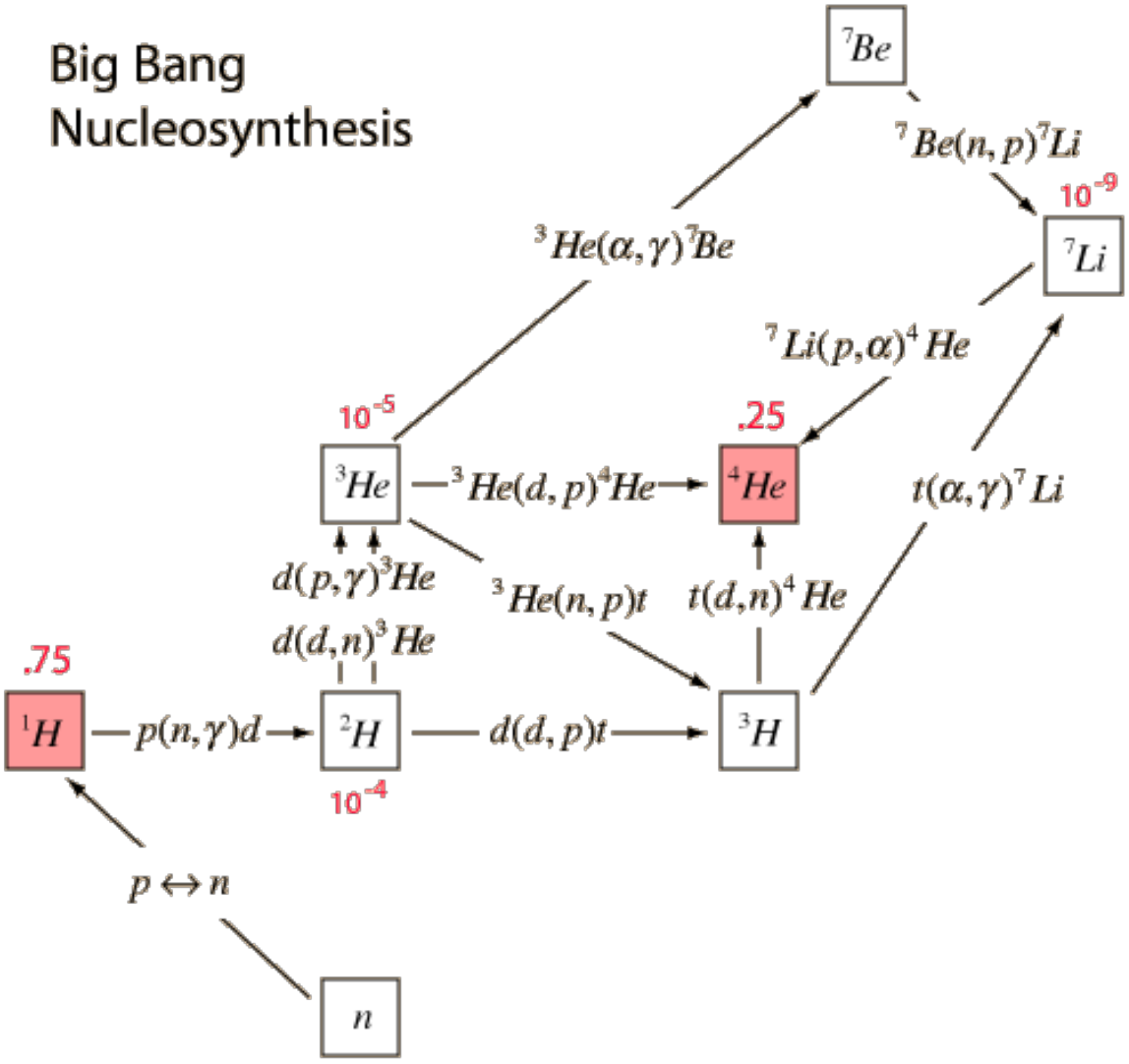
Heitur Miklihvellur

Lemaître og frumatómið - 1931

Kjarnasamruni í frumheimi - 1948



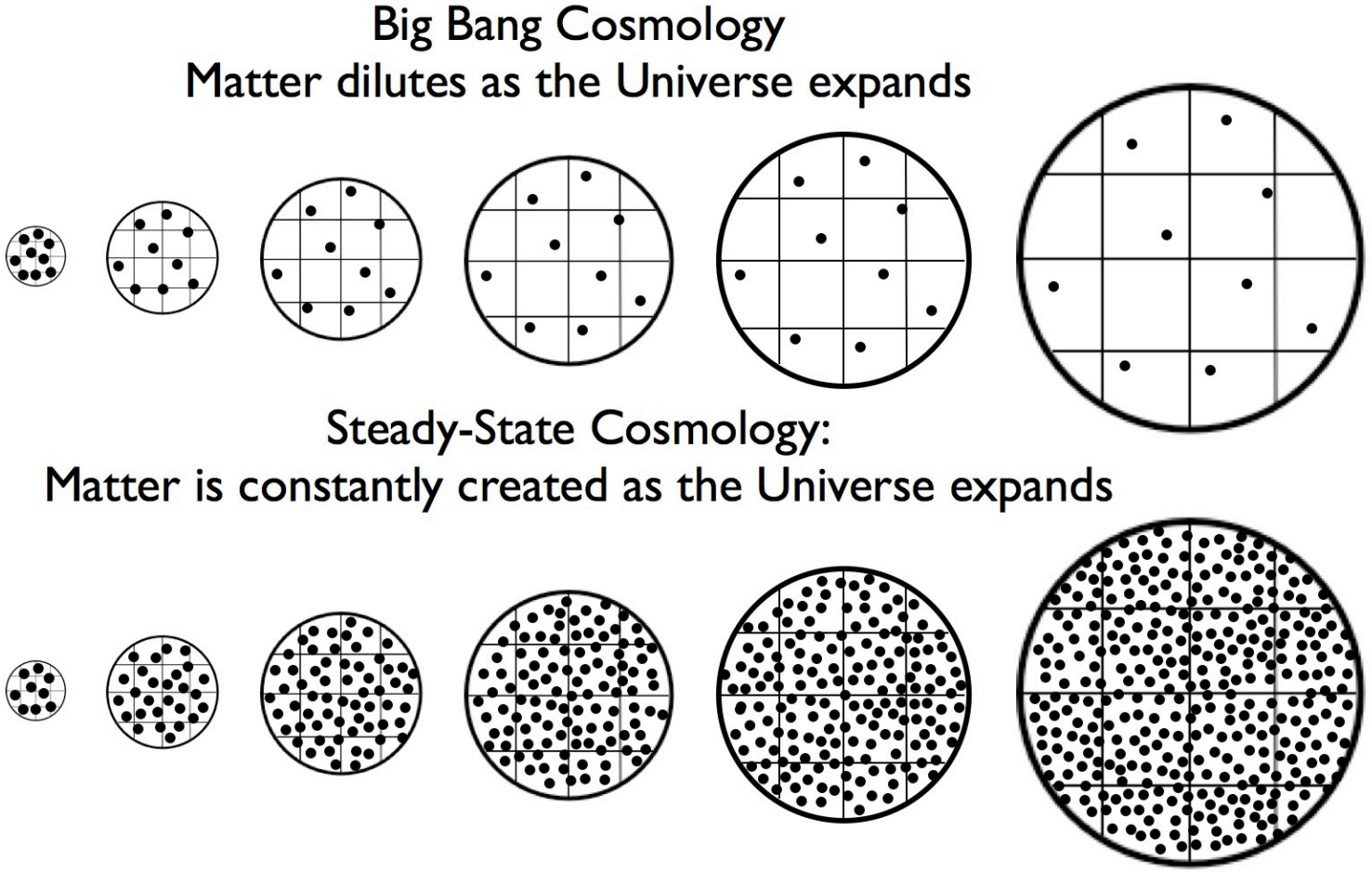
Frá vinstri: Robert Herman (1914-1947), Georg Gamow (1904-1968) og Ralph Alpher (1921-2007)

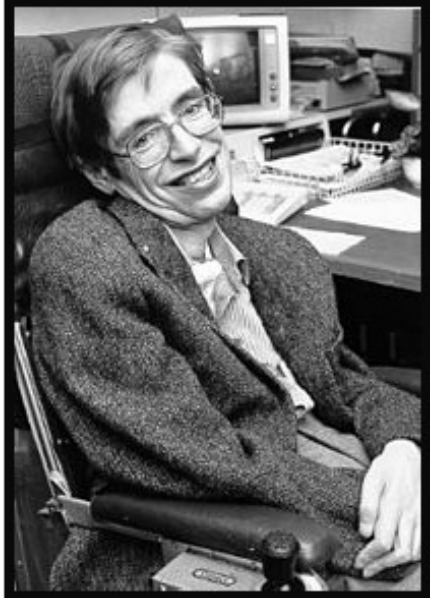

Big Bang
Nucleosynthesis
^{7}Be
$^{7}Be(n,p)^{7}Li$
10^{-9}
^{7}Li
$^{3}He(\alpha,\gamma)^{7}Be$
$^{7}Li(p,\alpha)^{4}He$
10^{-5}
.25
^{3}He
$^{3}He(d,p)^{4}He$
^{4}He
$t(\alpha,\gamma)^{7}Li$
$d(p,\gamma)^{3}He$
$^{3}He(n,p)t$
$t(d,n)^{4}He$
$d(d,n)^{3}He$
.75
^{1}H
$p(n,\gamma)d$
^{2}H
$d(d,p)t$
^{3}H
10^{-4}
$p \leftrightarrow n$
n

Jafnstöðukenningin - 1948

Frá vinstri: Thomas Gold (1920-2004), Hermann Bondi (1919-2005) og Fred Hoyle (1915-2001)

Samanburður kenninga



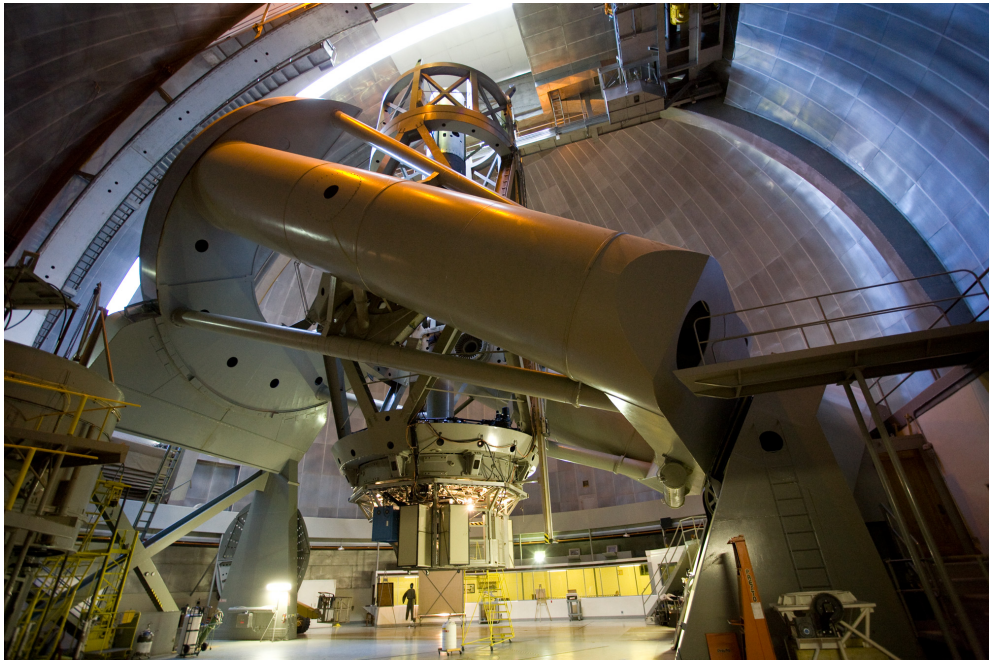


The Steady State theory was what Karl Popper would call a good scientific theory: it made definite predictions, which could be tested by observation, and possibly falsified. Unfortunately for the theory, they were falsified.

(Stephen Hawking)

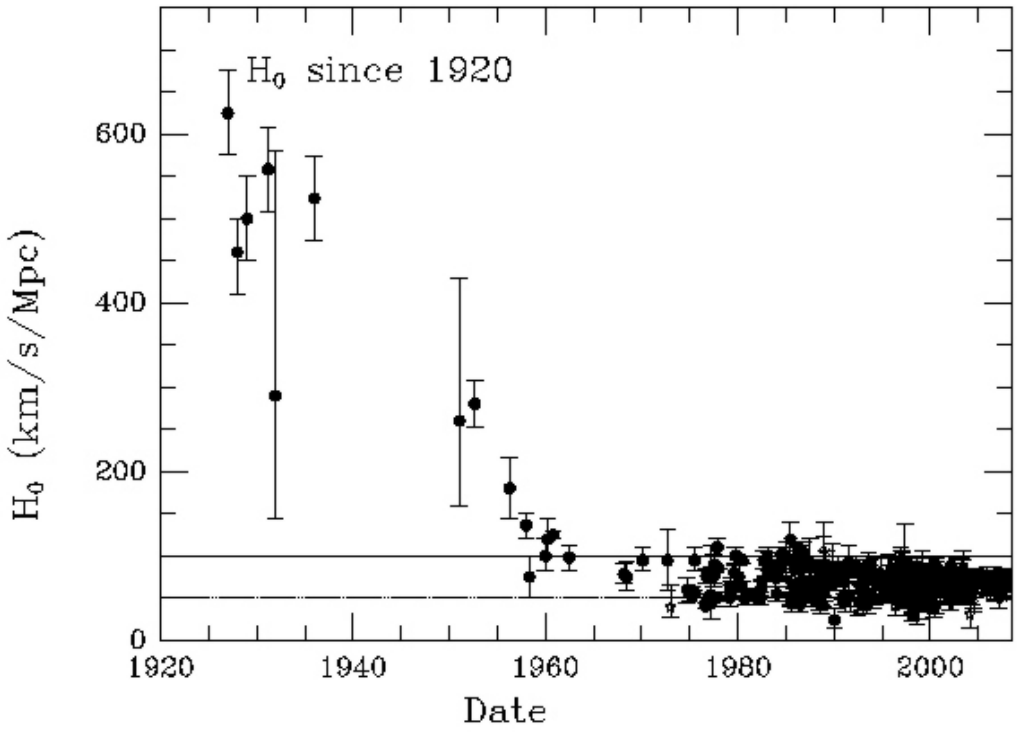
Leitin að rétta Miklahvellslíkaninu

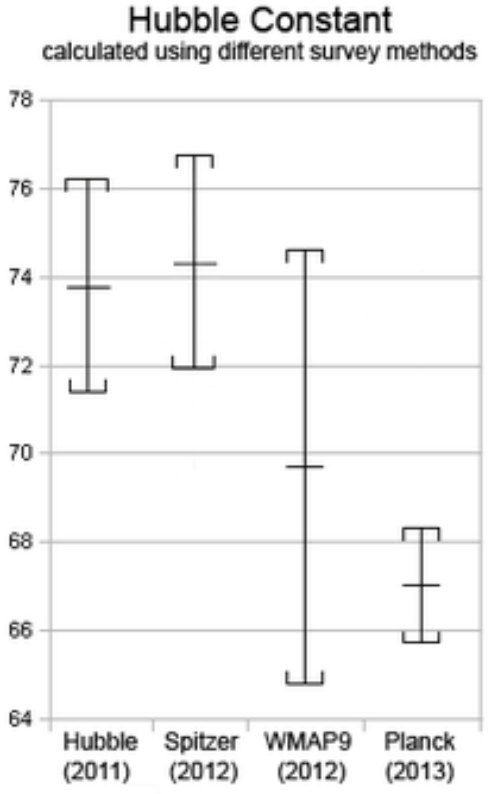
Alan Sandage (1926-2010)



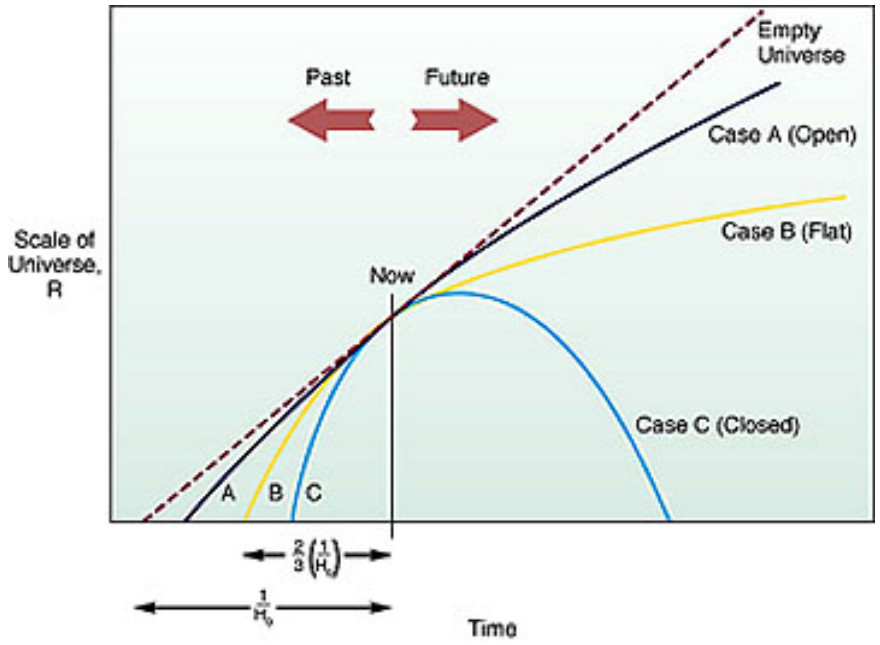
Hale sjónaukinn á Palomarfjalli.
Þvermál spegils = 5 m (200 þumlungar)

Mælingar á Hubblesstuðli

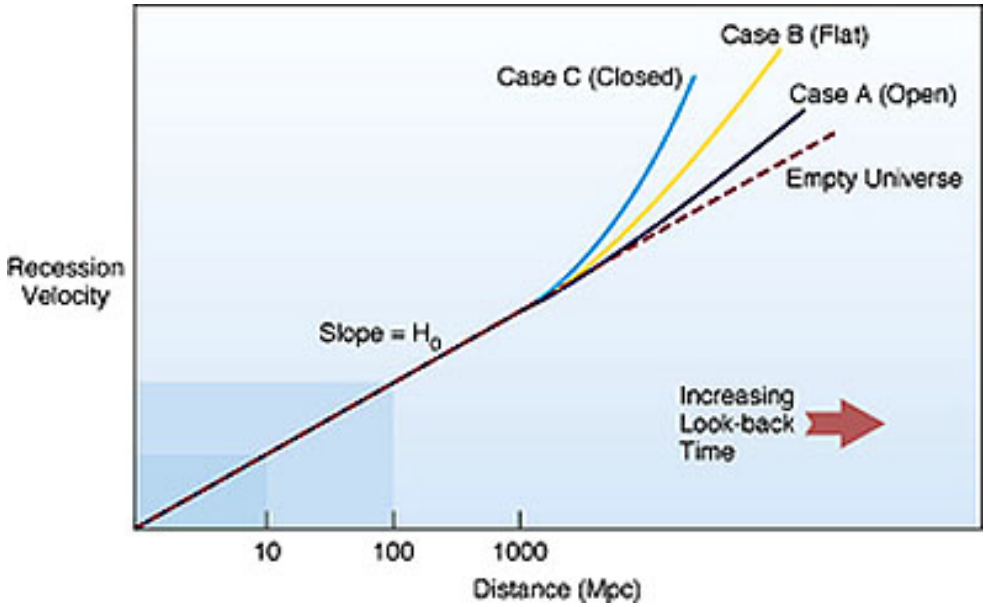




Heimslíkön afstæðiskenningarinnar án heimsfasta



Skalarþáttur: R = R(t)



Hubbleslínurit: $V = H_0 d$
ef fjarlægðir eru ekki of miklar

Útvarpsstjörnufræði

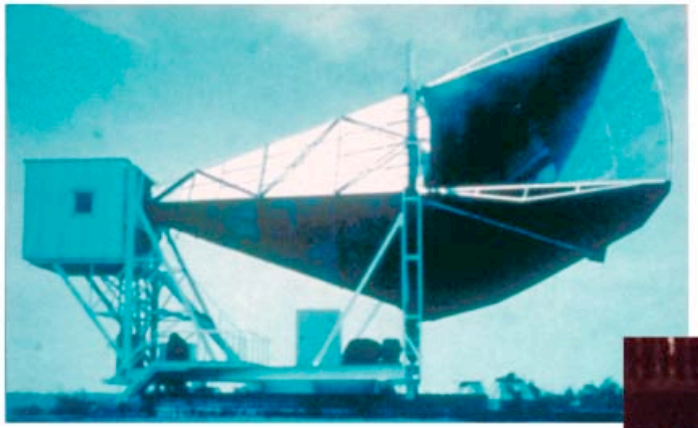
Martin Ryle (1918-1984)
við útvarssjónauka í Cambridge

EVLA (Expanded Very Large Array): 5 af 27
útvarpssjónaukum í New Mexico.

Örbylgjukliðurinn

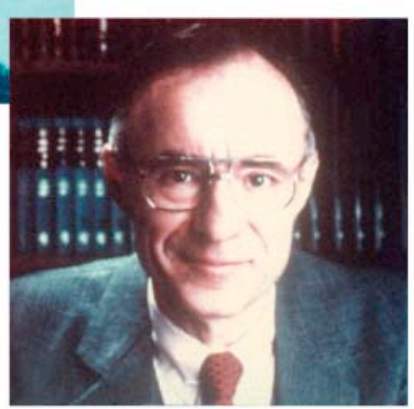
Örbylgjukliðurinn uppgötvaður 1964

DISCOVERY OF COSMIC BACKGROUND



Microwave Receiver

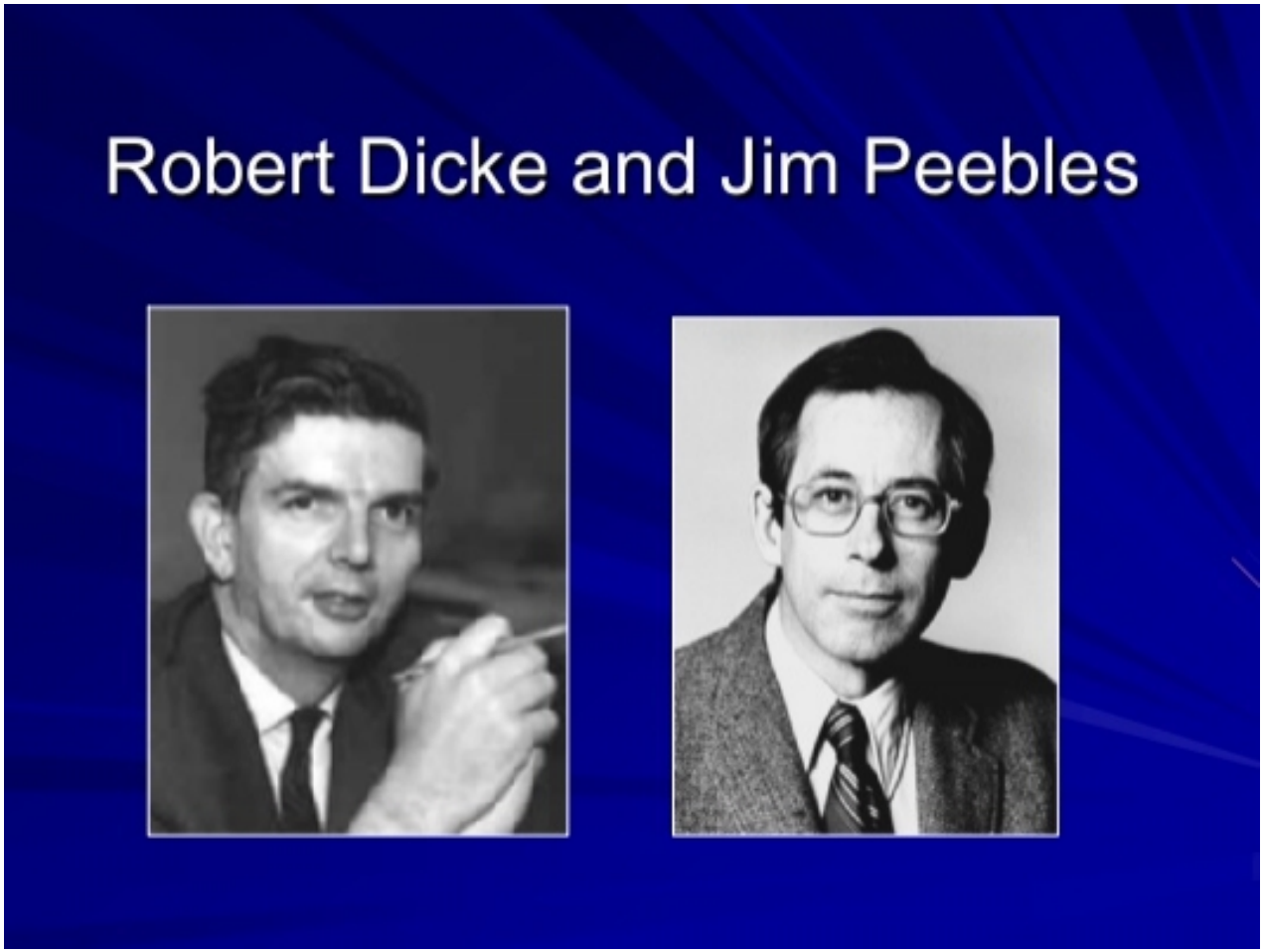
Robert Wilson
(f. 1933)



Arno Penzias
(f. 1936)

MAP990045

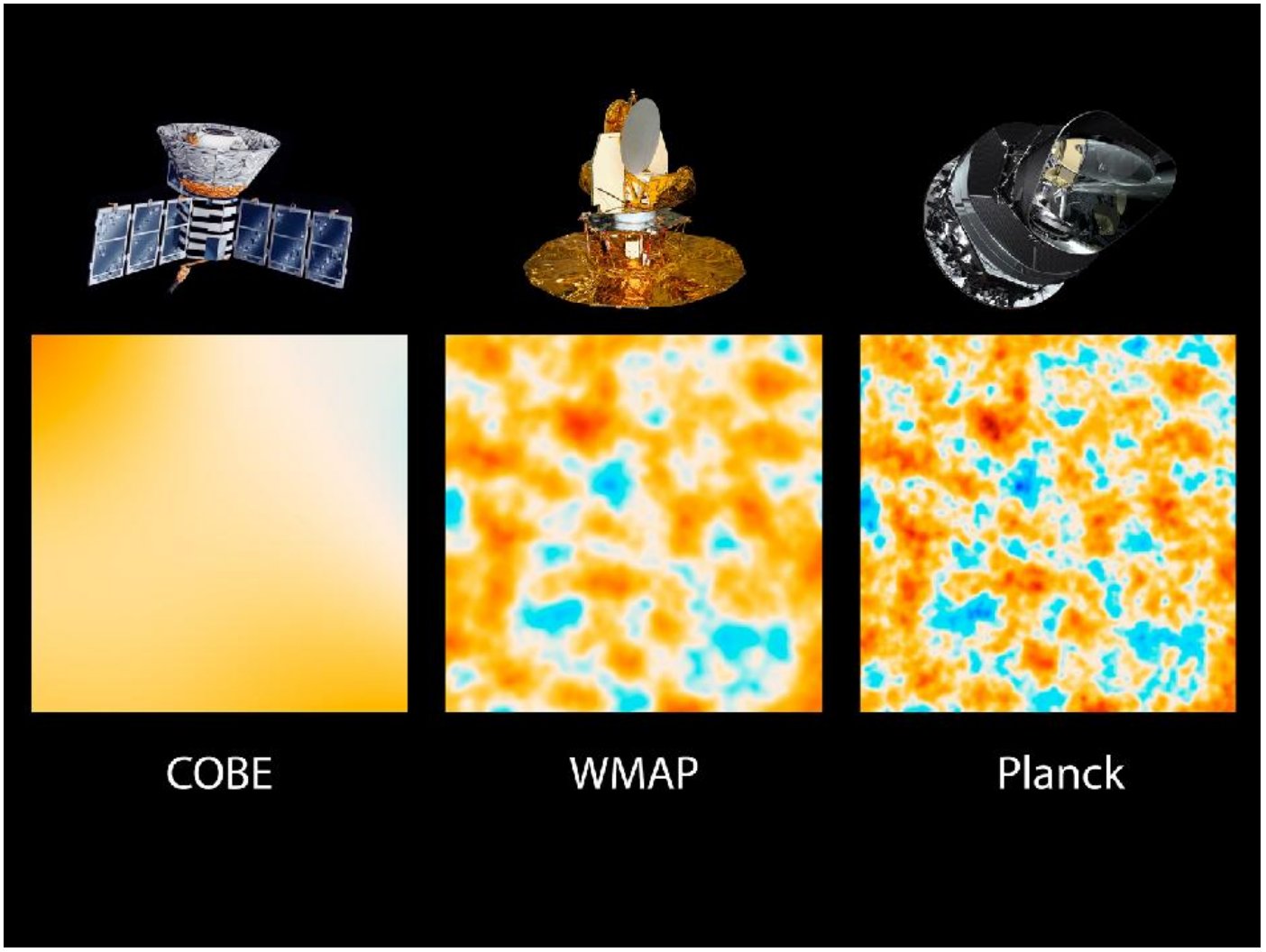
Kenningasmiðirnir við Princetonháskóla



(1916-1997)

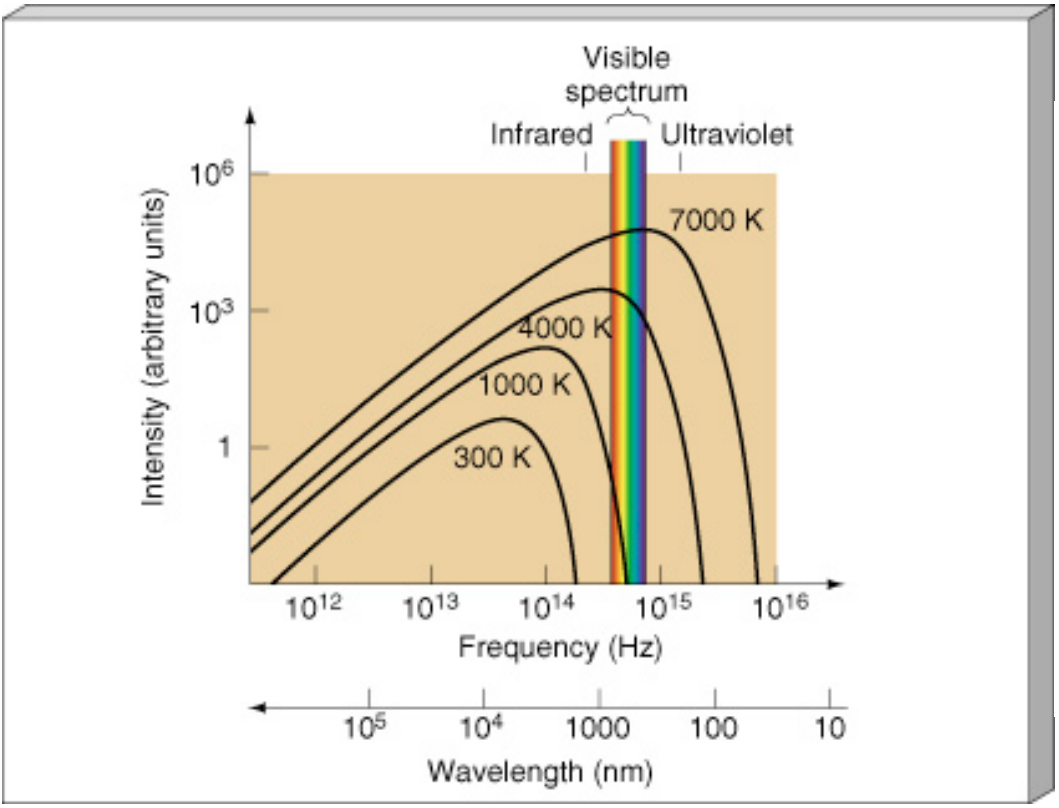
(f. 1935)

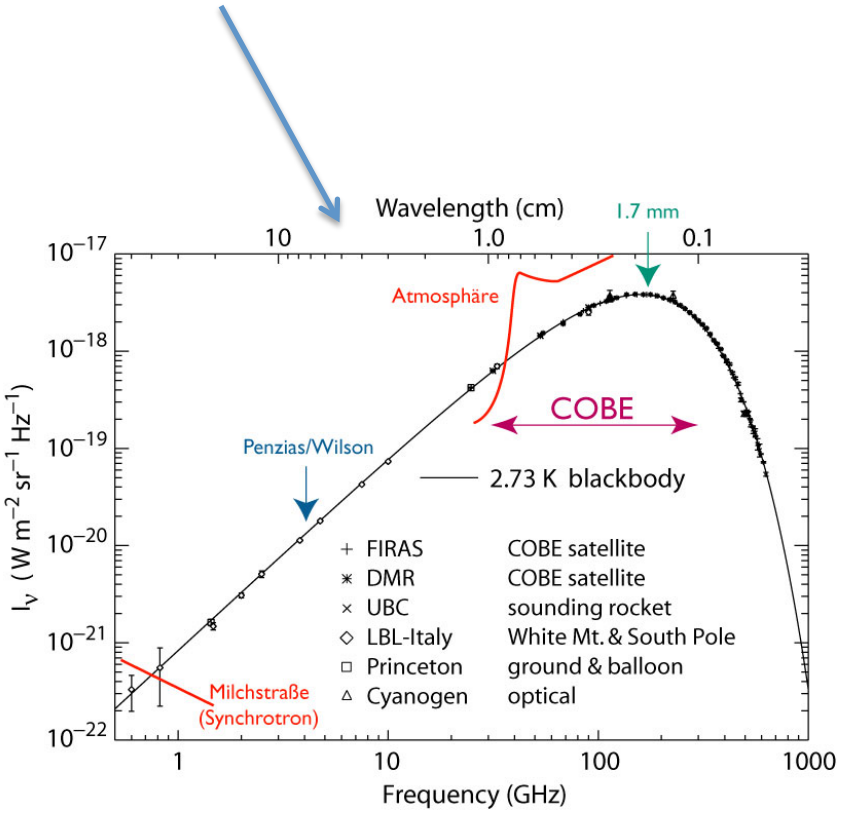
Mælingar í geimnum



Túlkun

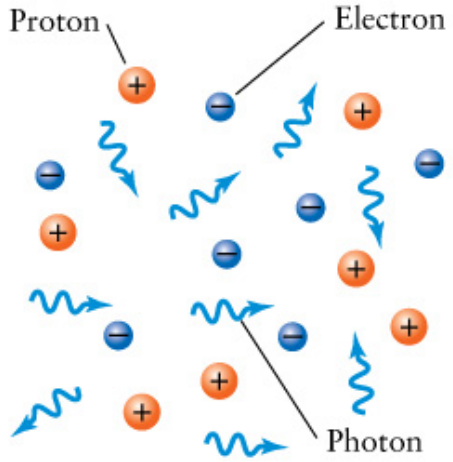
Orkuróf örbylgjukliðsins

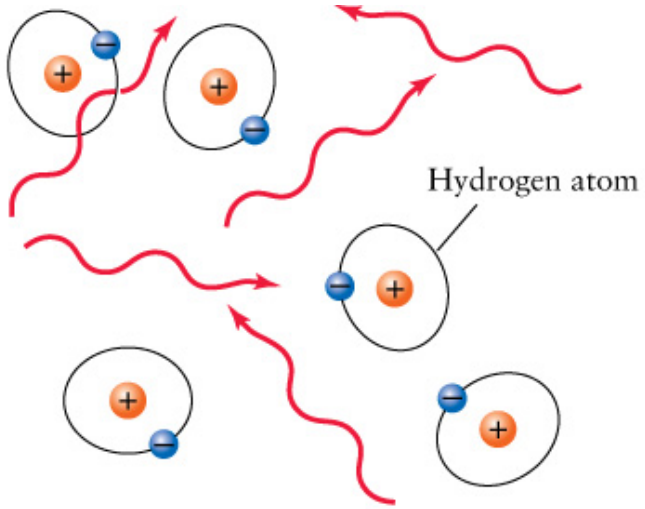




Orkuróf svarthlutargeislunar

380 þúsund árum eftir Miklahvell

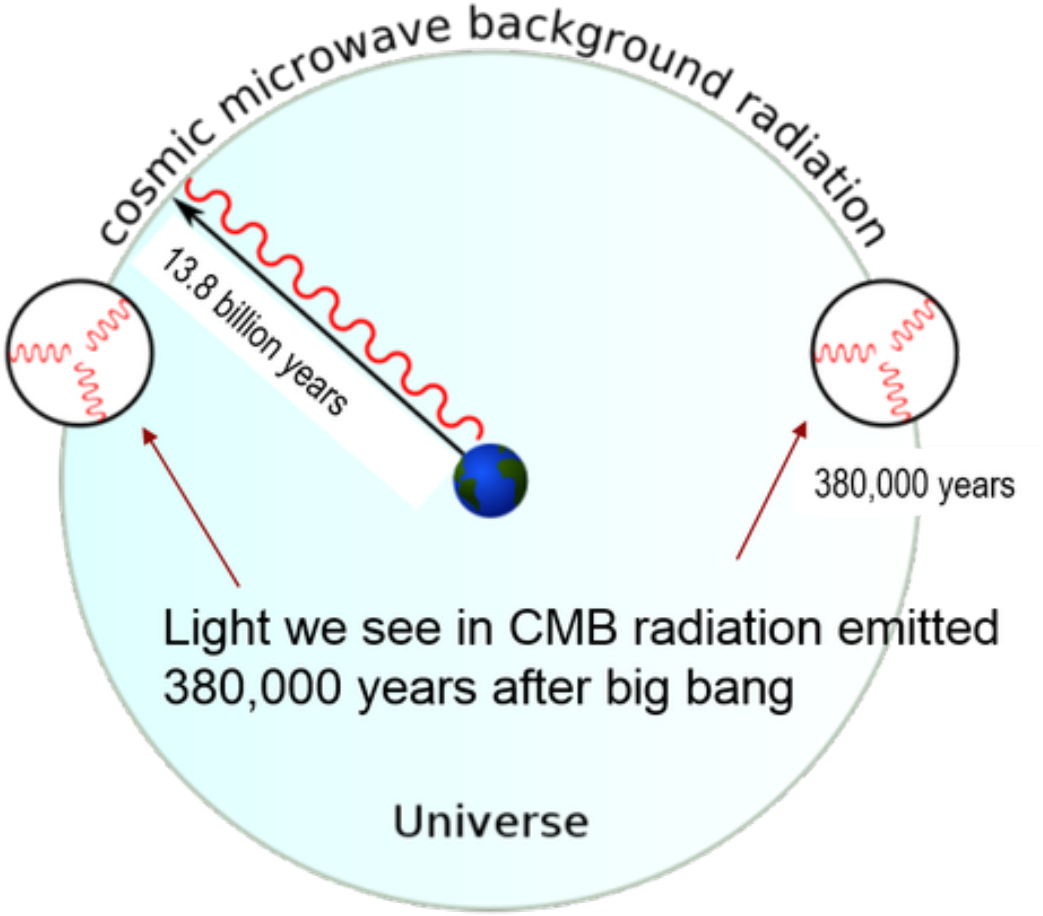




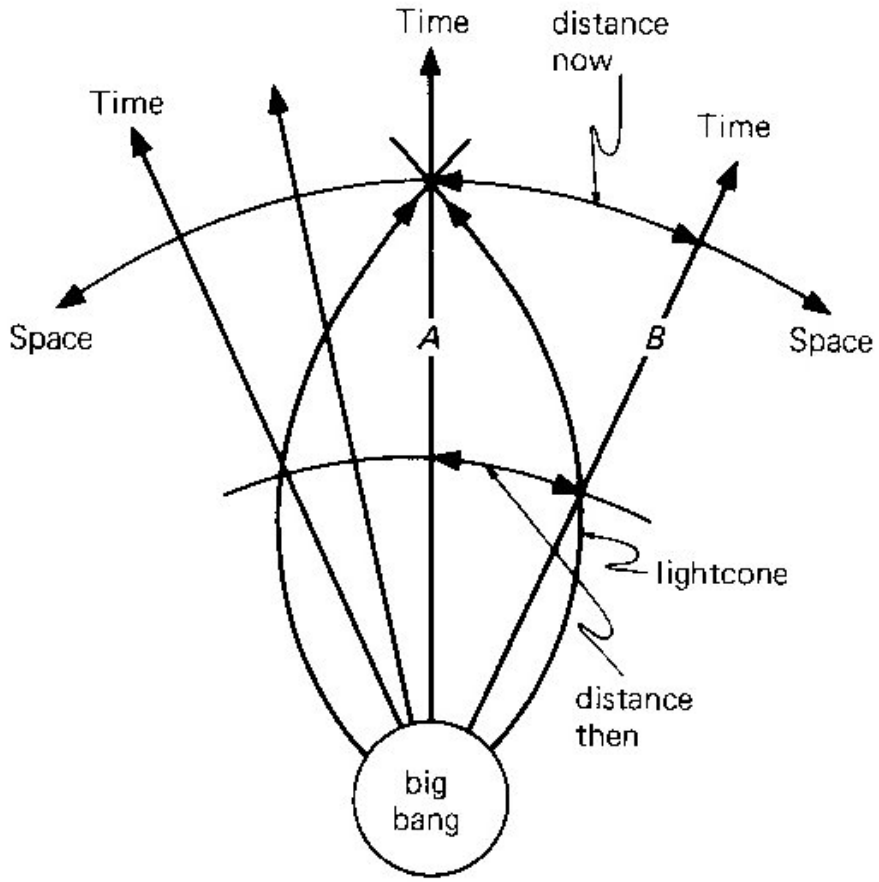
(a) Before recombination:
- Temperatures were so high that electrons and protons could not combine to form hydrogen atoms.
- The universe was opaque: Photons underwent frequent collisions with electrons.
- Matter and radiation were at the same temperature.

(b) After recombination:
- Temperatures became low enough for hydrogen atoms to form.
- The universe became transparent: Collisions between photons and atoms became infrequent.
- Matter and radiation were no longer at the same temperature.

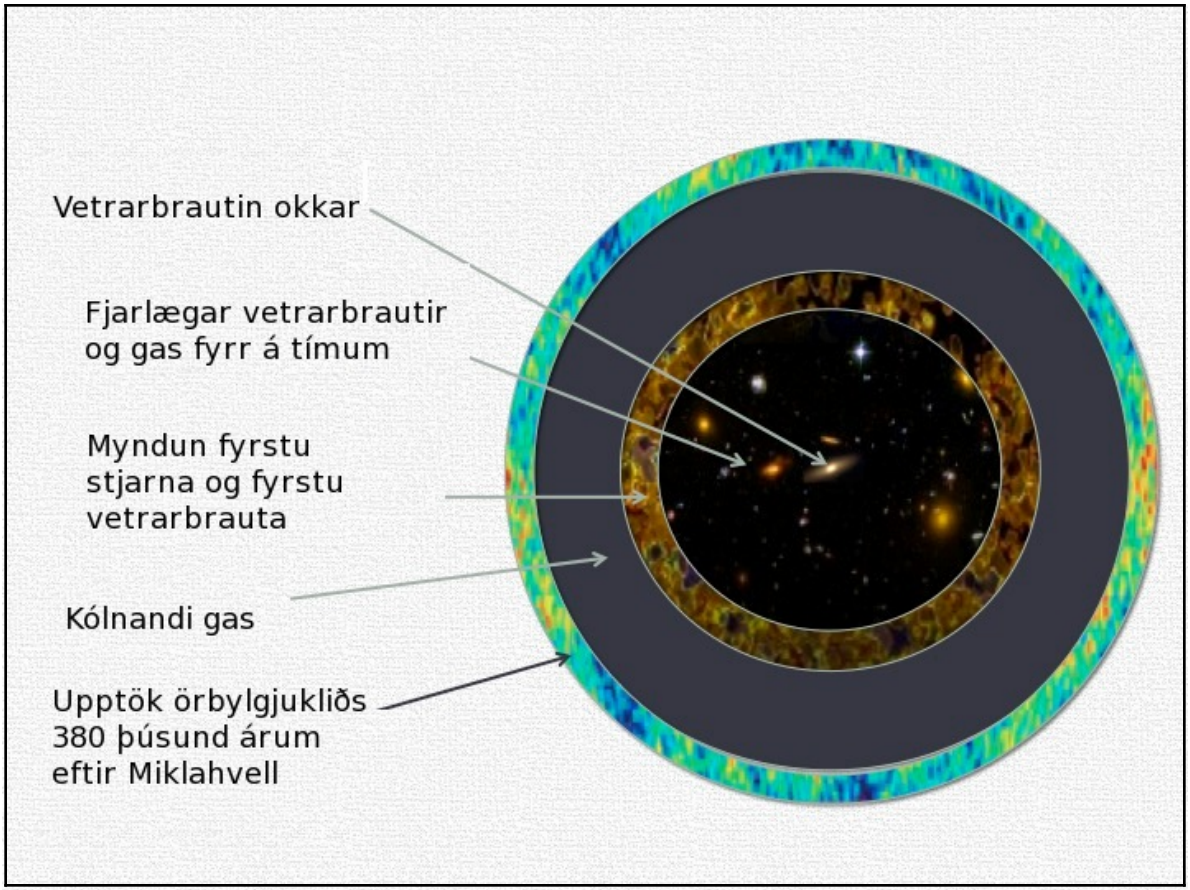
Ljóshvolf hins sýnilega heims



Fortíðarkeilan = Sýnilegur heimur

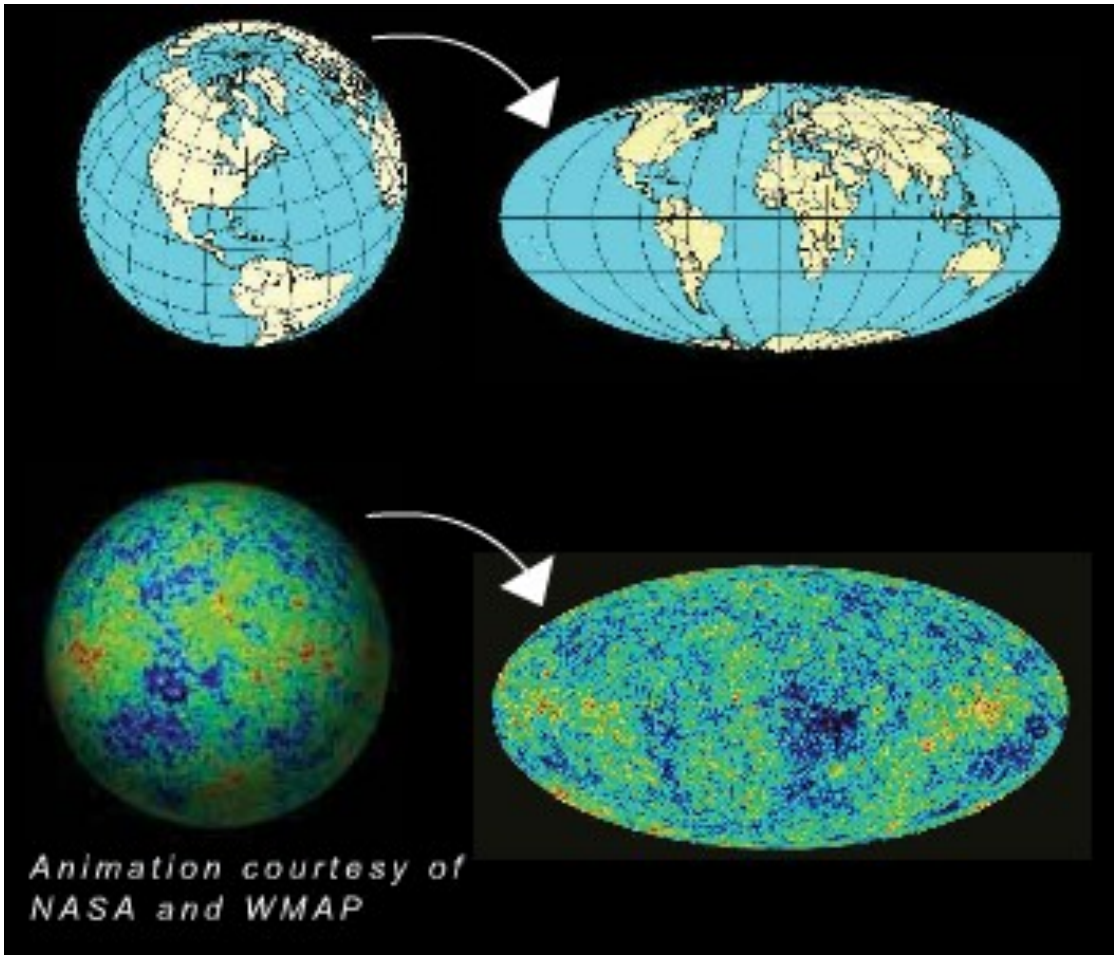


Hinn sýnilegi heimur

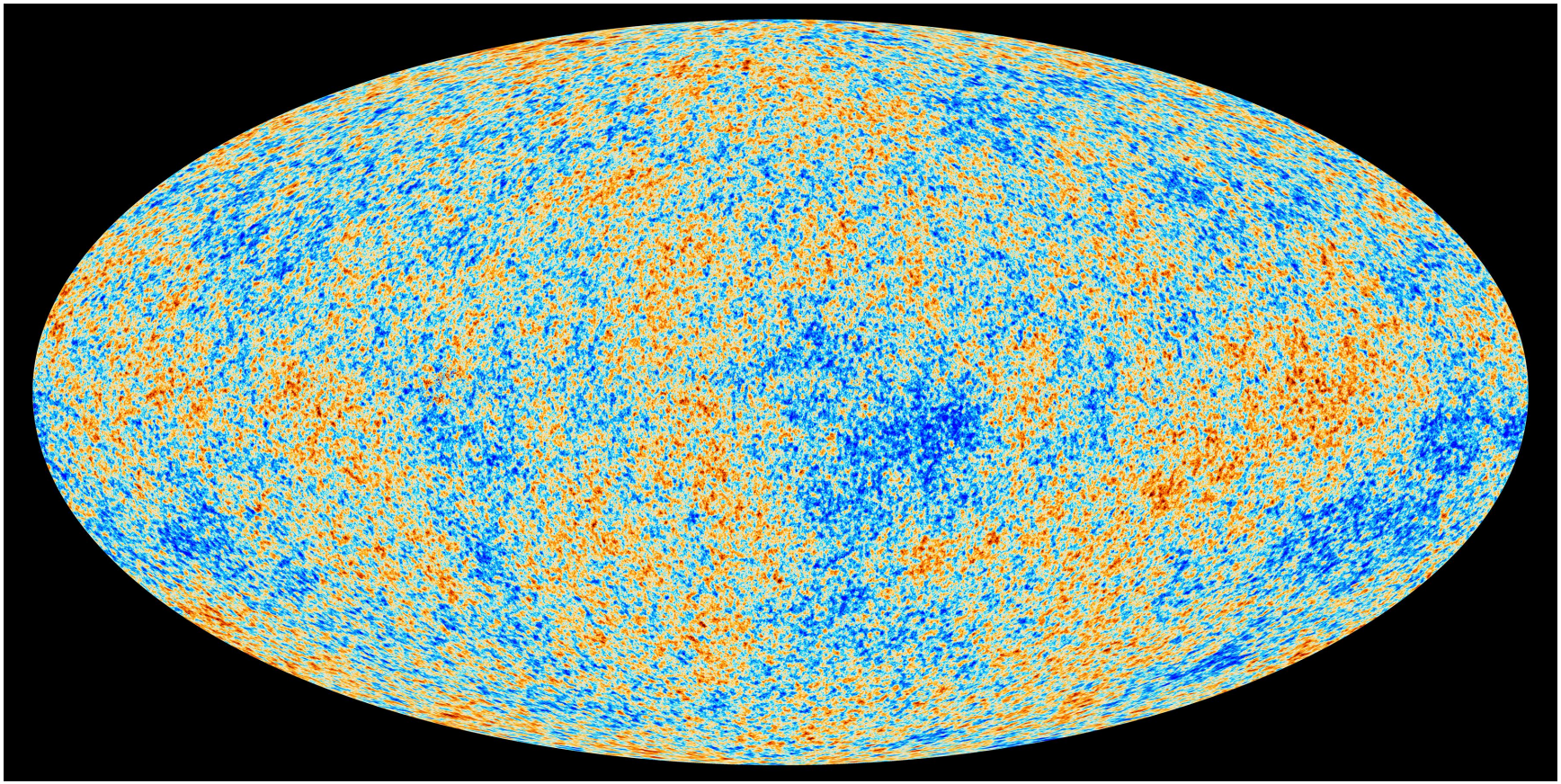


Horft út í geiminn = skyggnst aftur í tímann, lengst 14 milljarða ára.
Hér og nú er í miðjunni. Miklihvellur (upphafið) er á jaðrinum.
Við höfum engar upplýsingar um það sem utar er (á undan Miklahvelli).

Myndræn framsetning mælinga

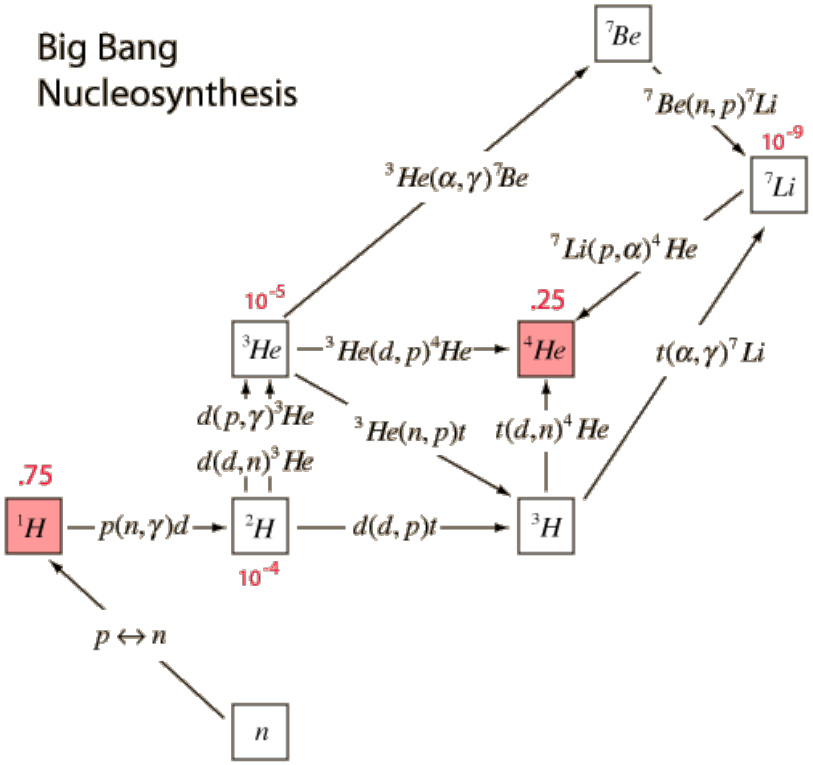


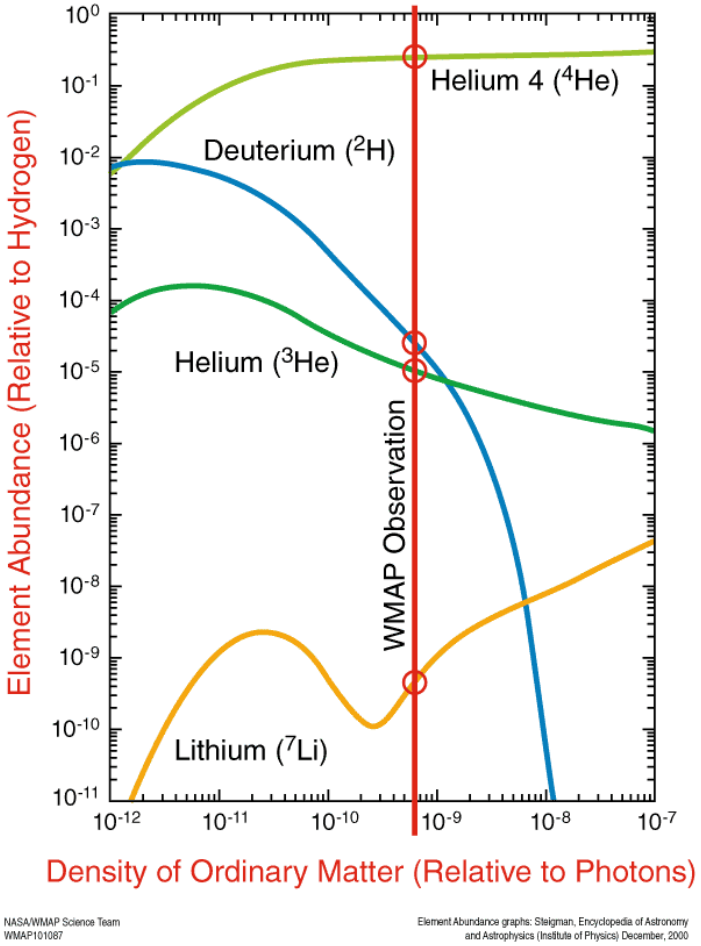
Virk sjóndeild: Ljóshvolf hins sýnilega heims



Mælingar Planck-geimrannsóknarstöðvarinnar á fráviki frá meðalhita örbylgjukliðsins (2,73 K) eftir að búið er að fjarlægja áhrif vegna hreyfingar sólkerfisins. Munurinn á heitustu svæðunum (rauður litur) og þeim köldustu (blár litur) mælist um 100 µK. Þegar geislunin lagði af stað voru um 380 þúsund ár liðin frá Miklahvelli.

Uppruni léttra frumefna 2





NASA/WMAP Science Team
WMAP101087

Element Abundance graphs: Steigman, Encyclopedia of Astronomy and Astrophysics (Institute of Physics) December, 2000

Hlutfallslegt magn frumefna 2

Í lok kjarnasamruna á fyrstu þremur mínútunum eftir Miklahvell var kjarnasamsetningin þessi (miðað við massa):

Vetni (H):	75%
Helín (He):	25%
Tvívetni (^{2}H):	0,001%
Liþín (Li).	< 0,001%

Efnasamsetning alheims í dag:

Vetni (H):	71%
Helín (He):	27%
Málmar:	2%

Málmar = Öll frumefni þyngri en Helín. Þeir verða til ásamt Helíni í kjarnahvörfum í stjörnum.

The Origin of the Solar System Elements

big bang fusion 

cosmic ray fission 

merging neutron stars 

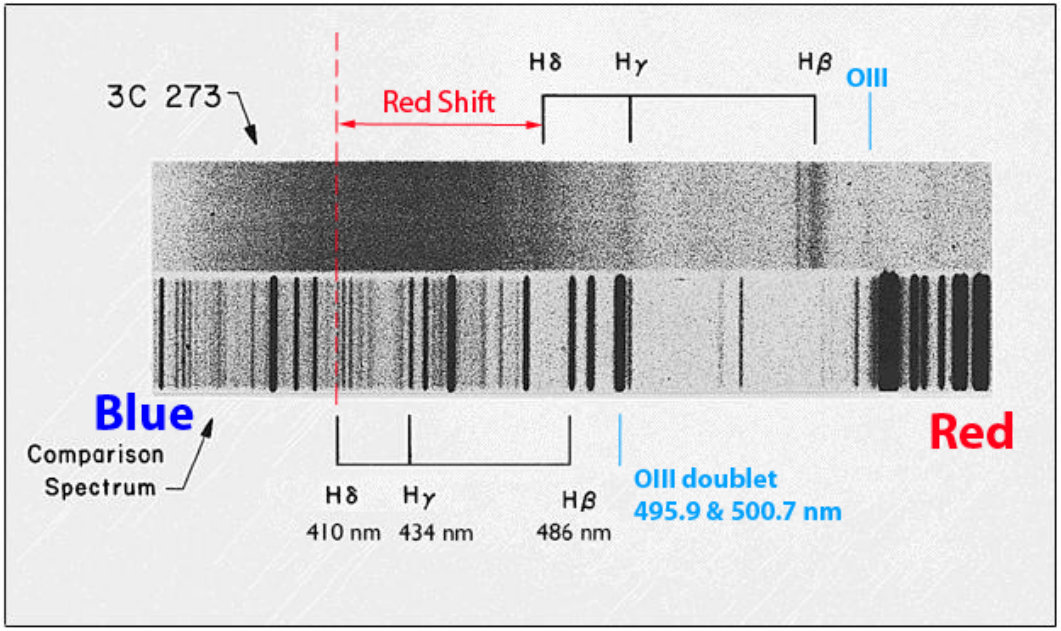
exploding massive stars 

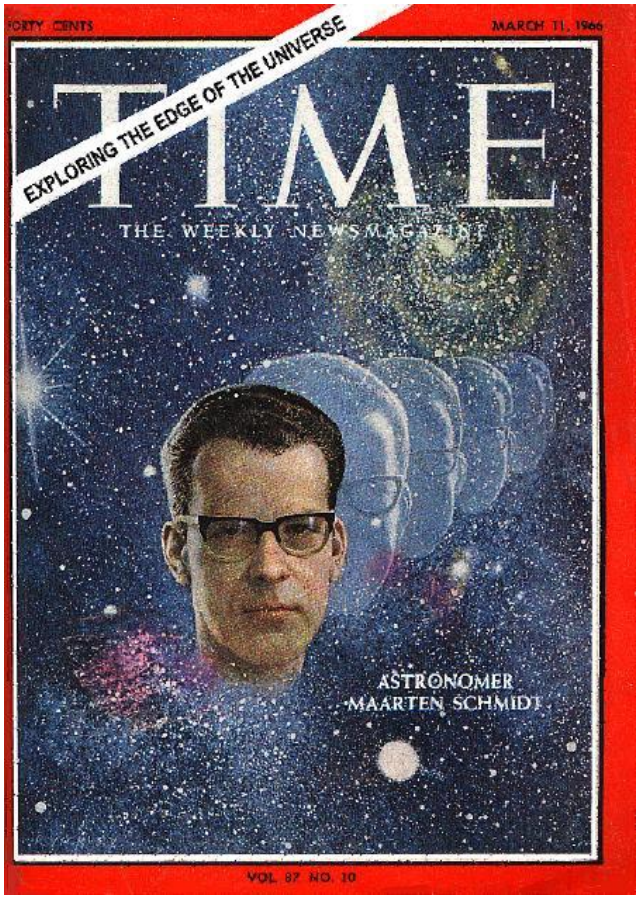
dying low mass stars 

exploding white dwarfs 

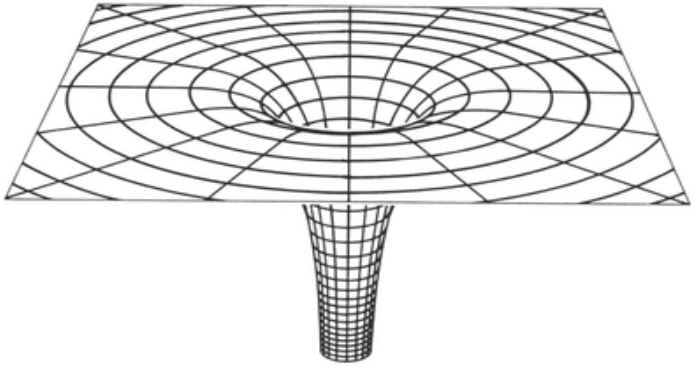
1 H																	2 He
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra																
			57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
			89 Ac	90 Th	91 Pa	92 U											

Dulstirni uppgötvuð 1963



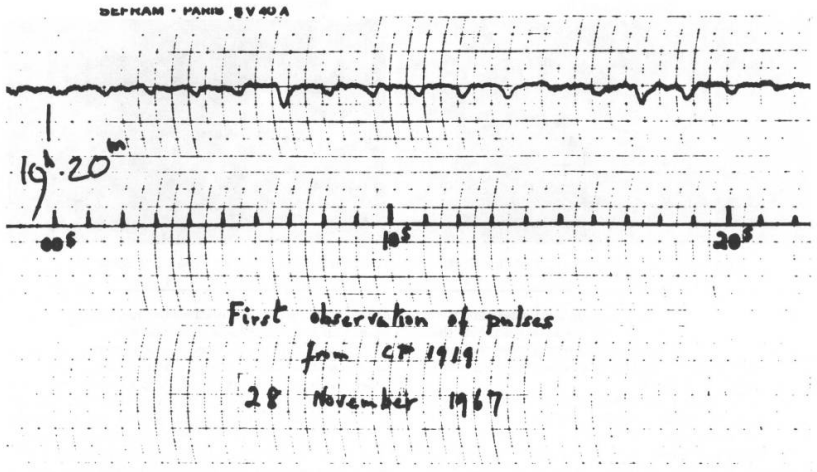


Líkan af dulstirni

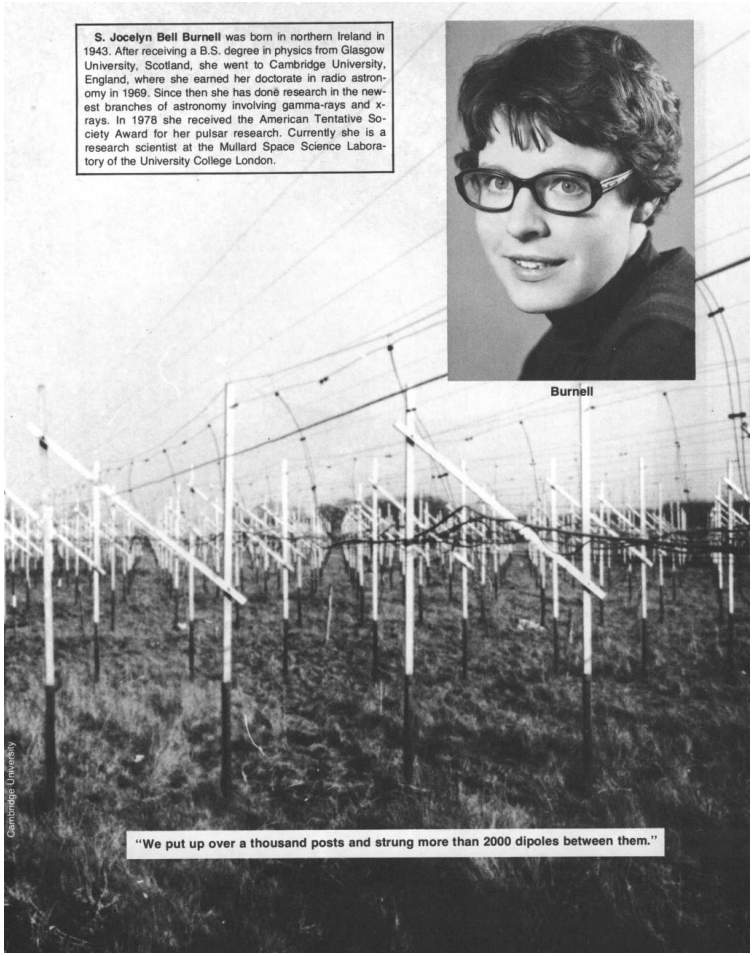


Svarthol

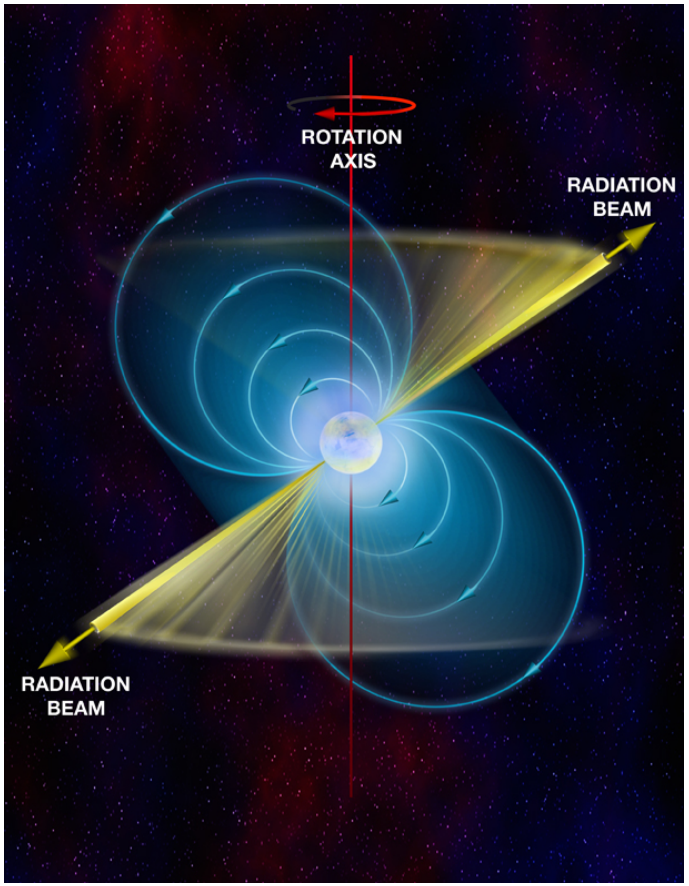
Tifstjörnur uppgötvaðar 1967



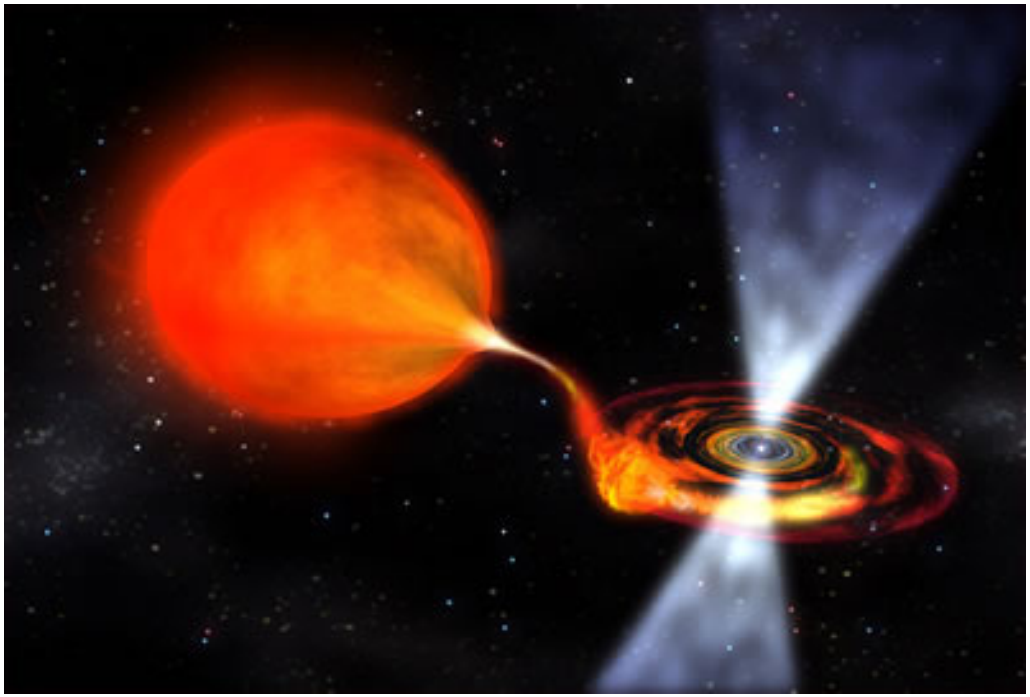
"I got it on a fast recording. As the chart flowed under the pen I could see that the signal was a series of pulses . . . 1⅓ seconds apart." (Deflections are down).



Nifteindastjörnur

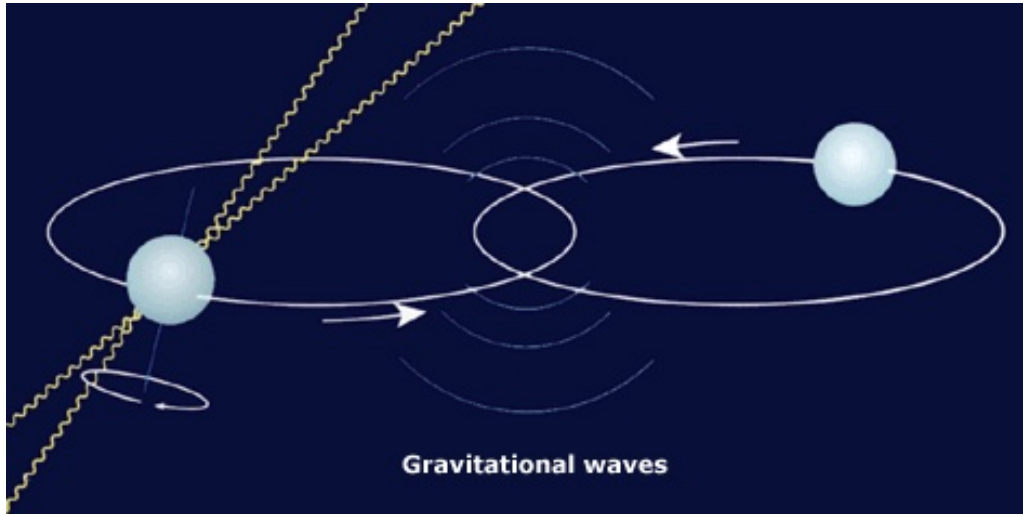


Tifstjarna

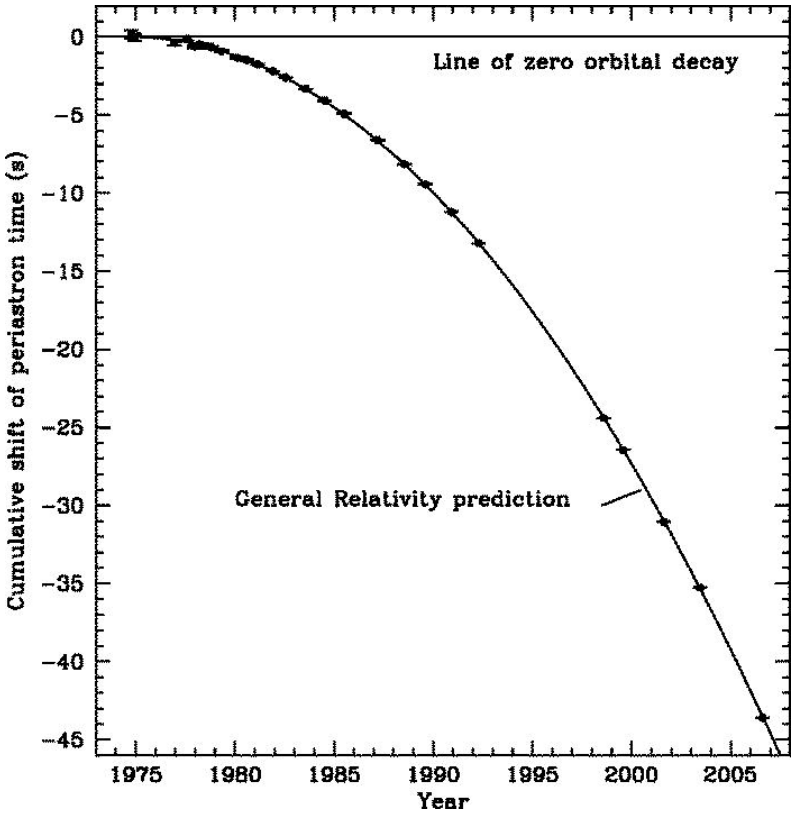


Röntgenslagstjarna

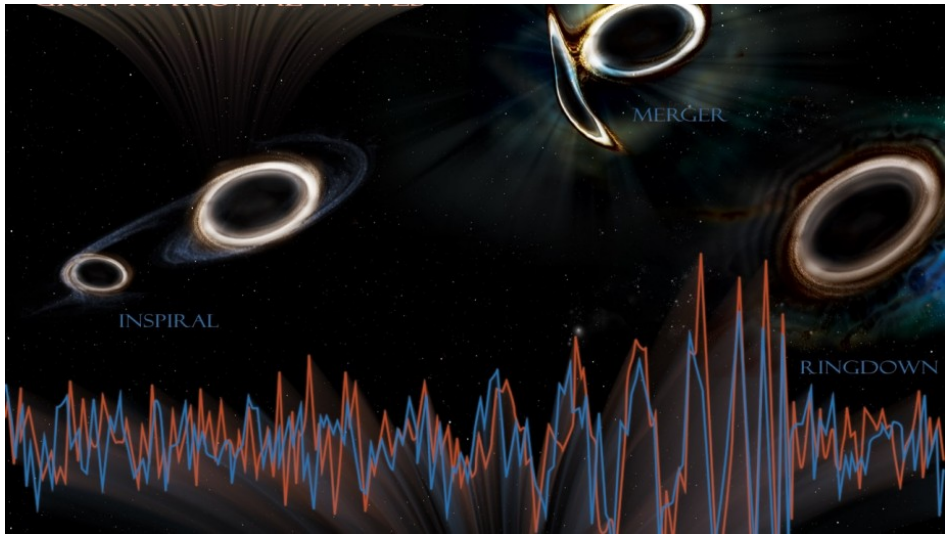
PSR 1913 + 16 og þyngdarbylgjur



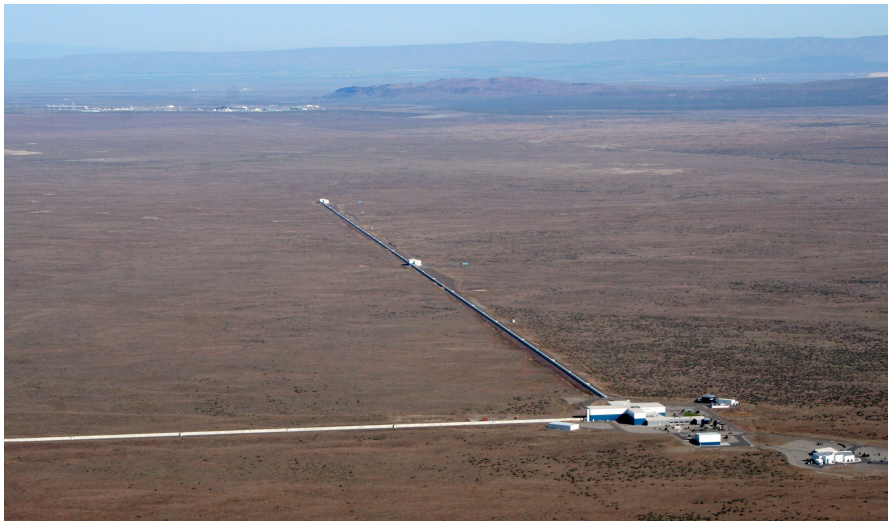
Tvær nifteindastjörnur í þéttstæðu tvístirni.
Fjarlægð: 0,5 - 2,4 sólarþvermál
Umferðartími: 7,8 klst



Mælingar á þyngdarbylgjum 2016

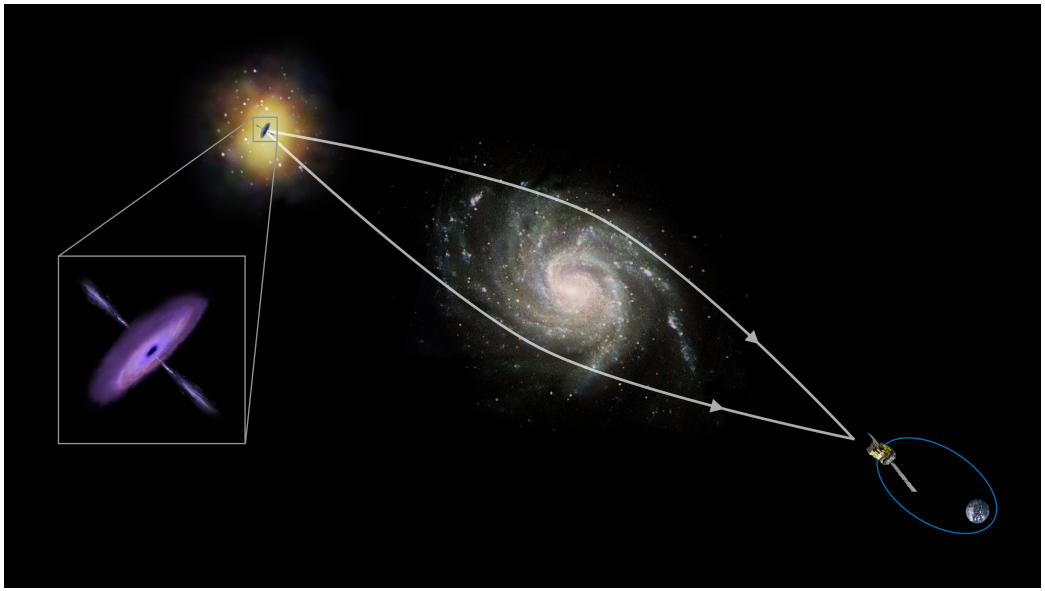


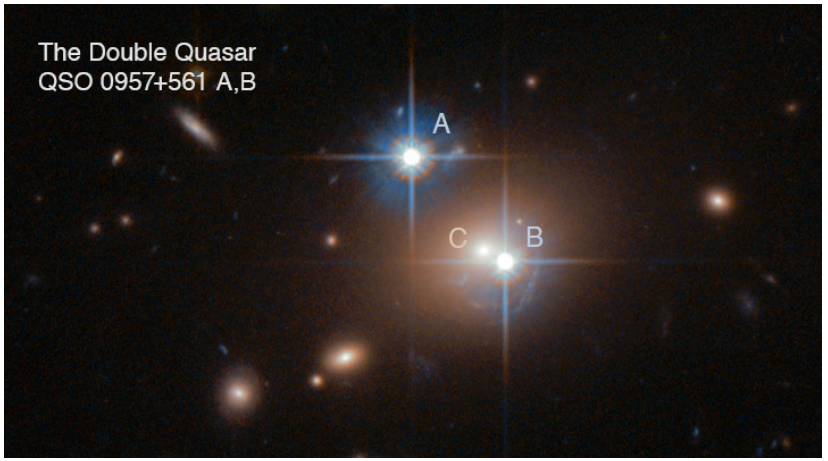
Árekstur tveggja svarthola



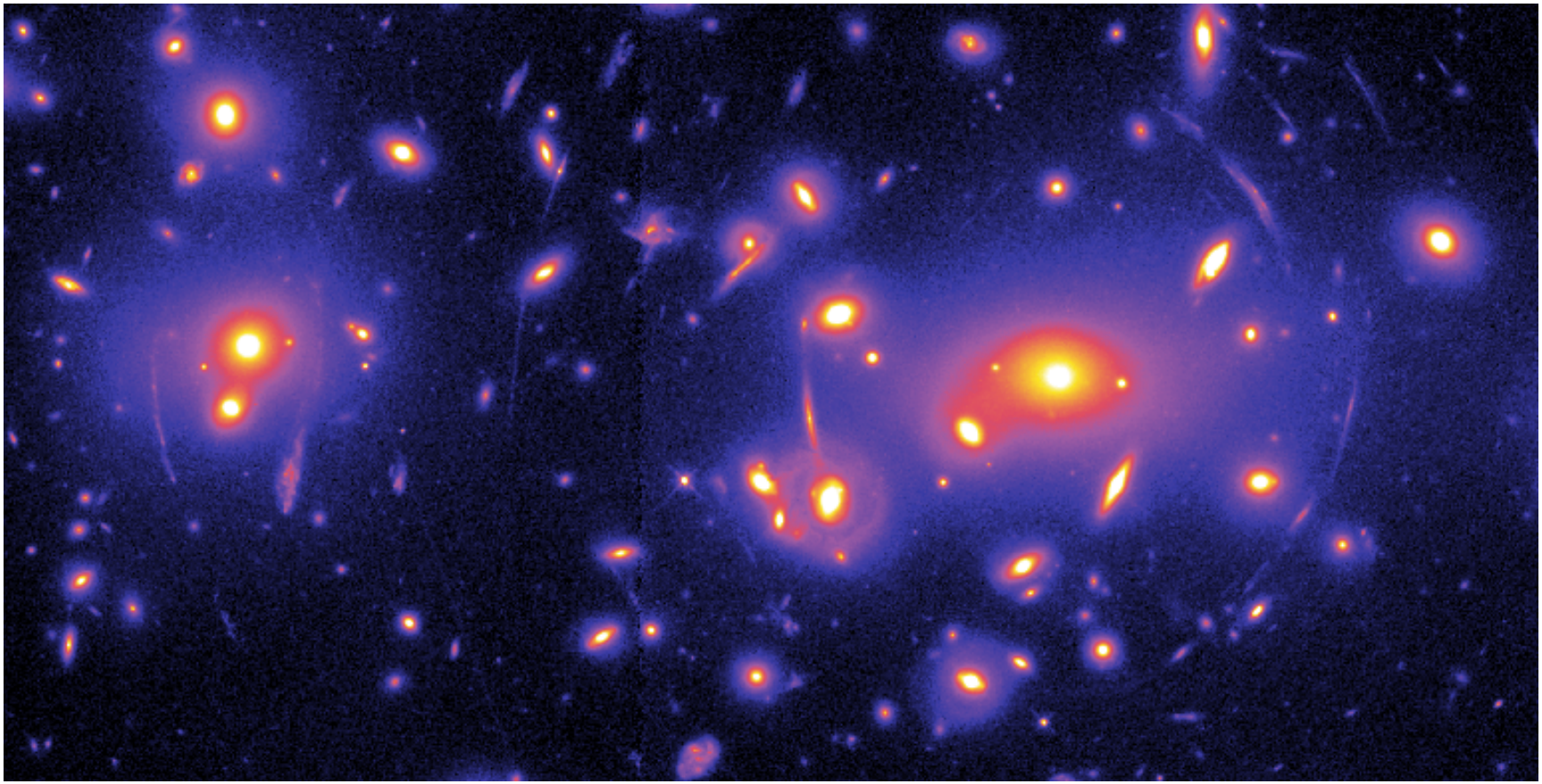
Önnur tveggja mælistöðva
LIGO samstafsins

Þyngdarlinsur



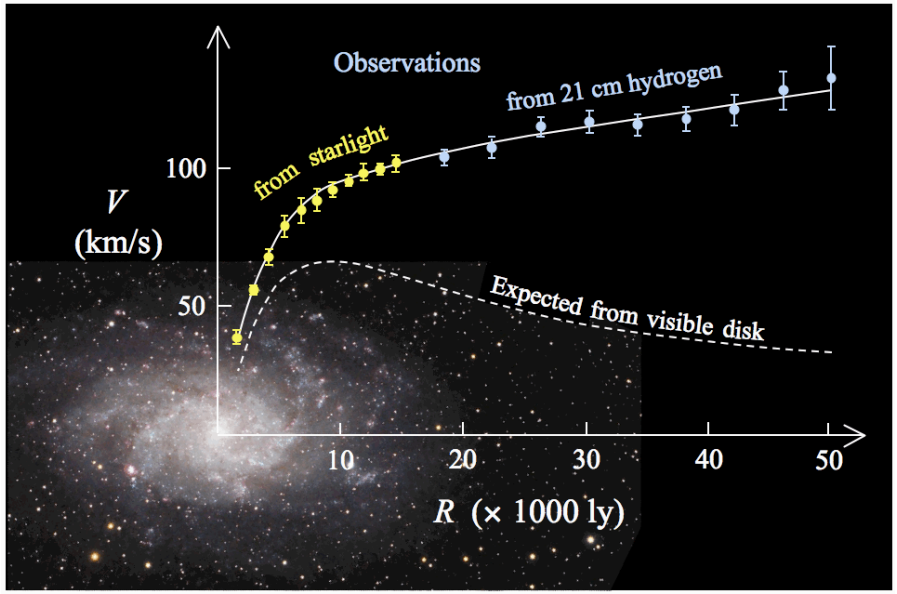


Veik linsuhrif og hulduefni

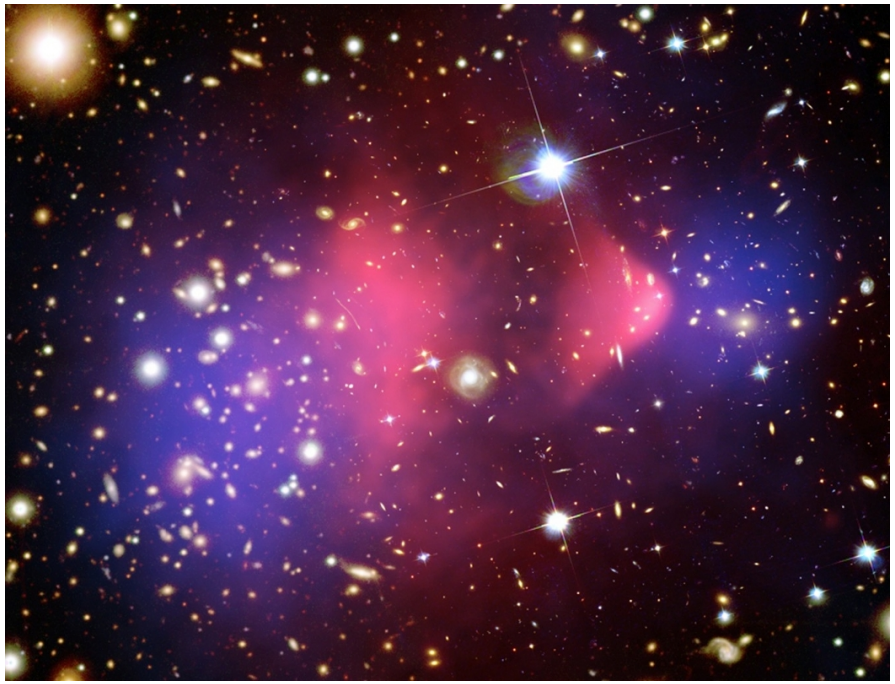


Abell 2218

Hulduefni



Massi hulduefnis (sést ekki) í dæmigerðri þyrilþoku veldur því að stjörnur og geimefni snúast mun hraðar um miðjuna en hægt er að skýra með þyngd sýnilega efnisins.



Árekstur tveggja vetrarbrautaþyrpinga. Eftir áreksturinn situr gasið (rautt) í þyrpingunum eftir, en hulduefnið (blátt) fylgir vetrarbrautunum.