



Robert Oppenheimer
1904-1967



Leslie Richard Groves
1896– 1970

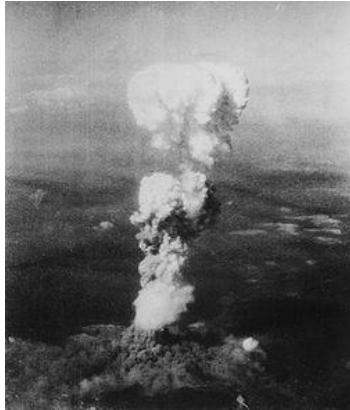
Manhattan Project



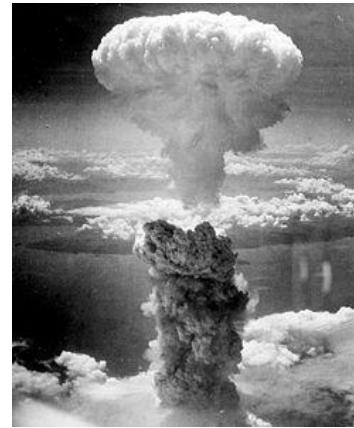
動用數千位科學、工程人員
花費超過20億美金



The Manhattan Project created the first [nuclear bombs](#). The first human-engineered [nuclear detonation](#), the [Trinity test](#), is shown.

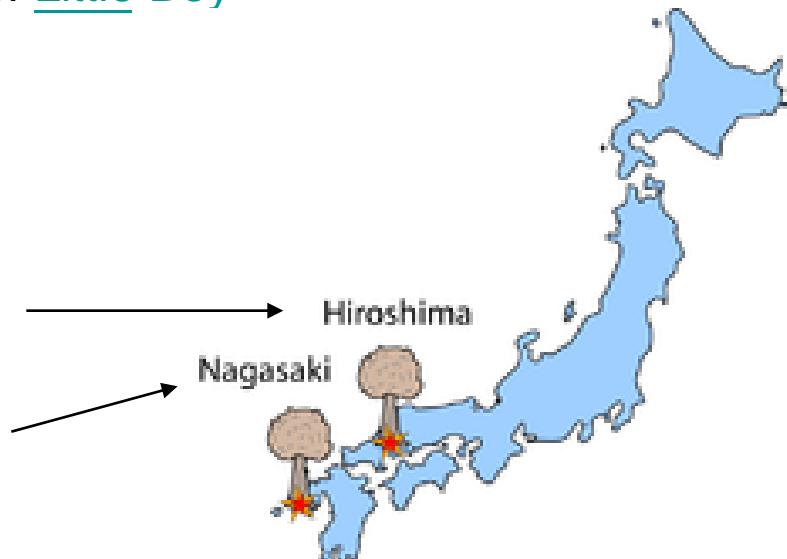


The mushroom cloud over Hiroshima after the dropping of Little Boy



The nuclear explosion over Nagasaki

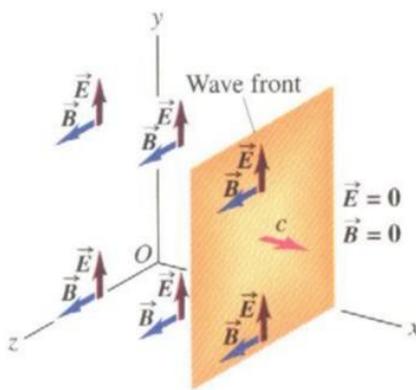
約 9 萬人死亡
約 4 萬人死亡



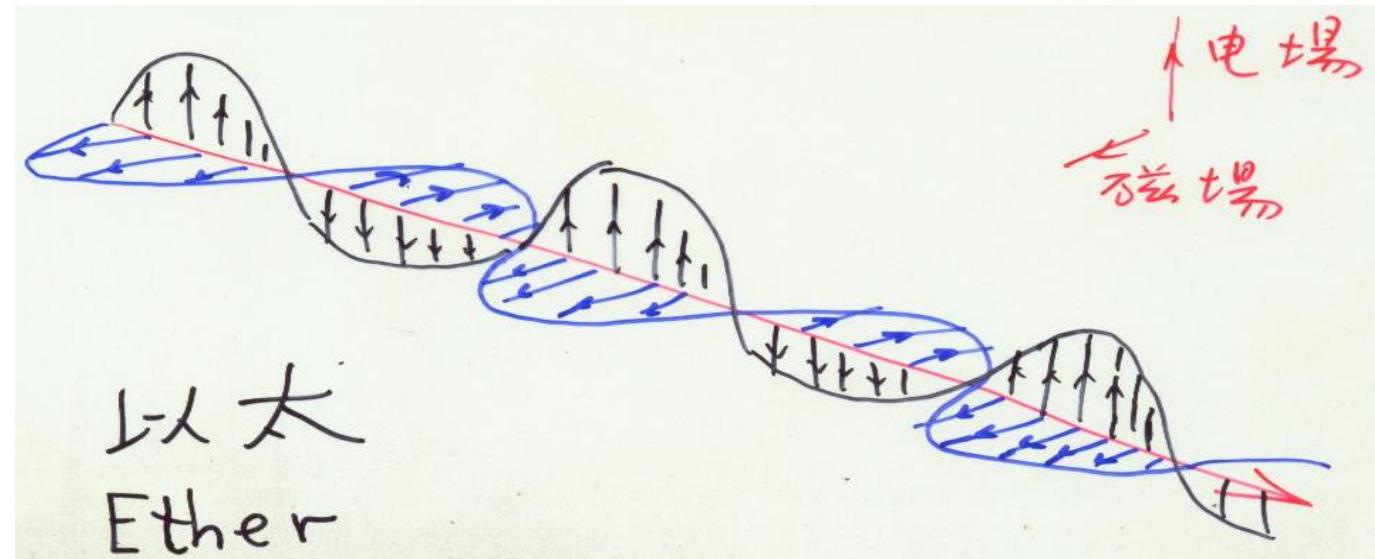
鼓動愛因斯坦上書羅斯福總統重視原子能研究的齊拉德(Szilard)就取得了數十位科學家的連署，呼籲杜魯門千萬要慎重。這些人準備了一份報告反對臨時委員會的建議，他們認為「不預警地對日本使用核子武器是不恰當的」。

馬克斯威爾(J. C. Maxwell, 1831-1879)

在1860年代以四個數學方程式來描述一切電與磁的現象。
他並且將光解釋為電磁波，也就是電場與磁場的振盪。



平面波



电场

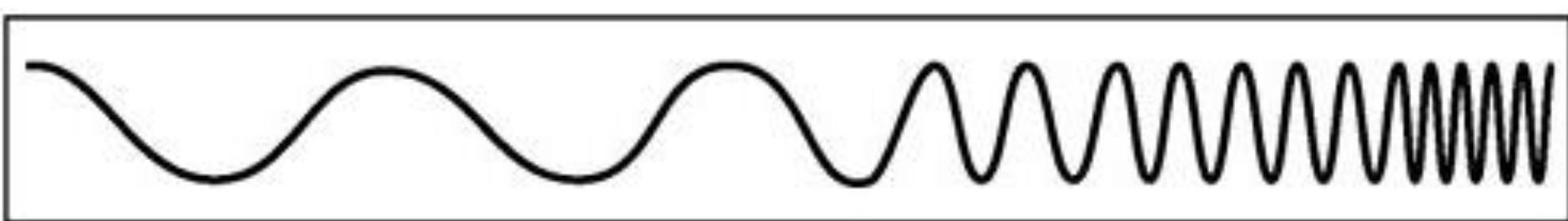
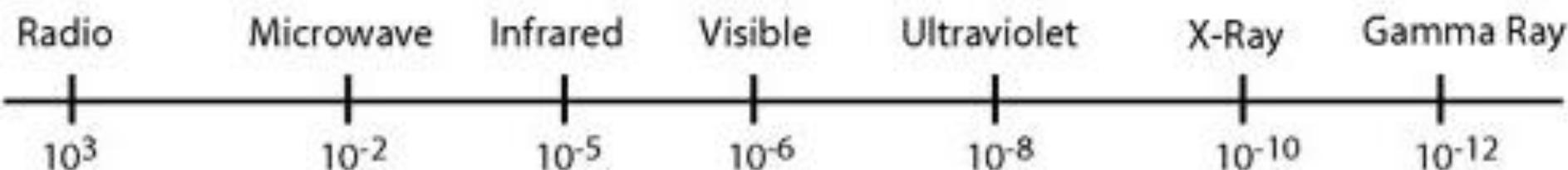
磁场

馬克斯威爾還算出光速(在以太座標)大約為每秒30萬公里 **光速 = c**

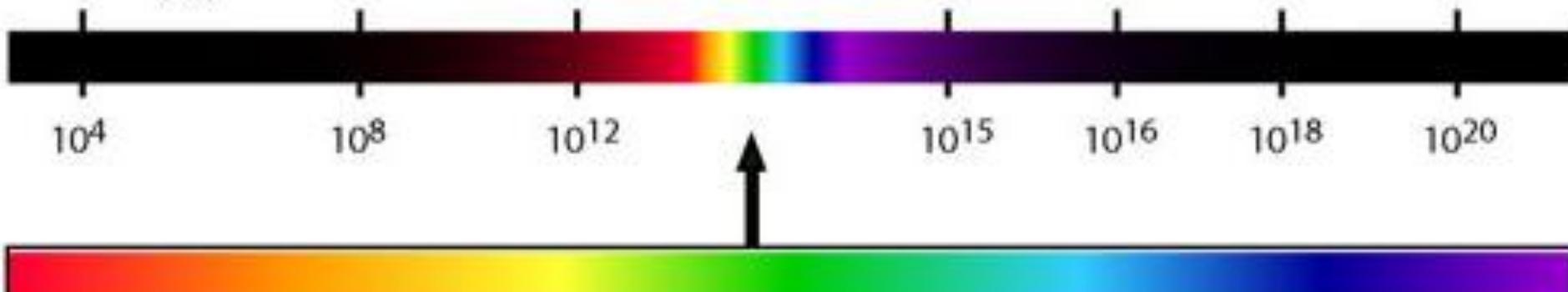
電磁波的能量密度和電場強度平方與磁場強度平方之和成正比，但和電磁波的頻率沒有關係。

THE ELECTRO MAGNETIC SPECTRUM

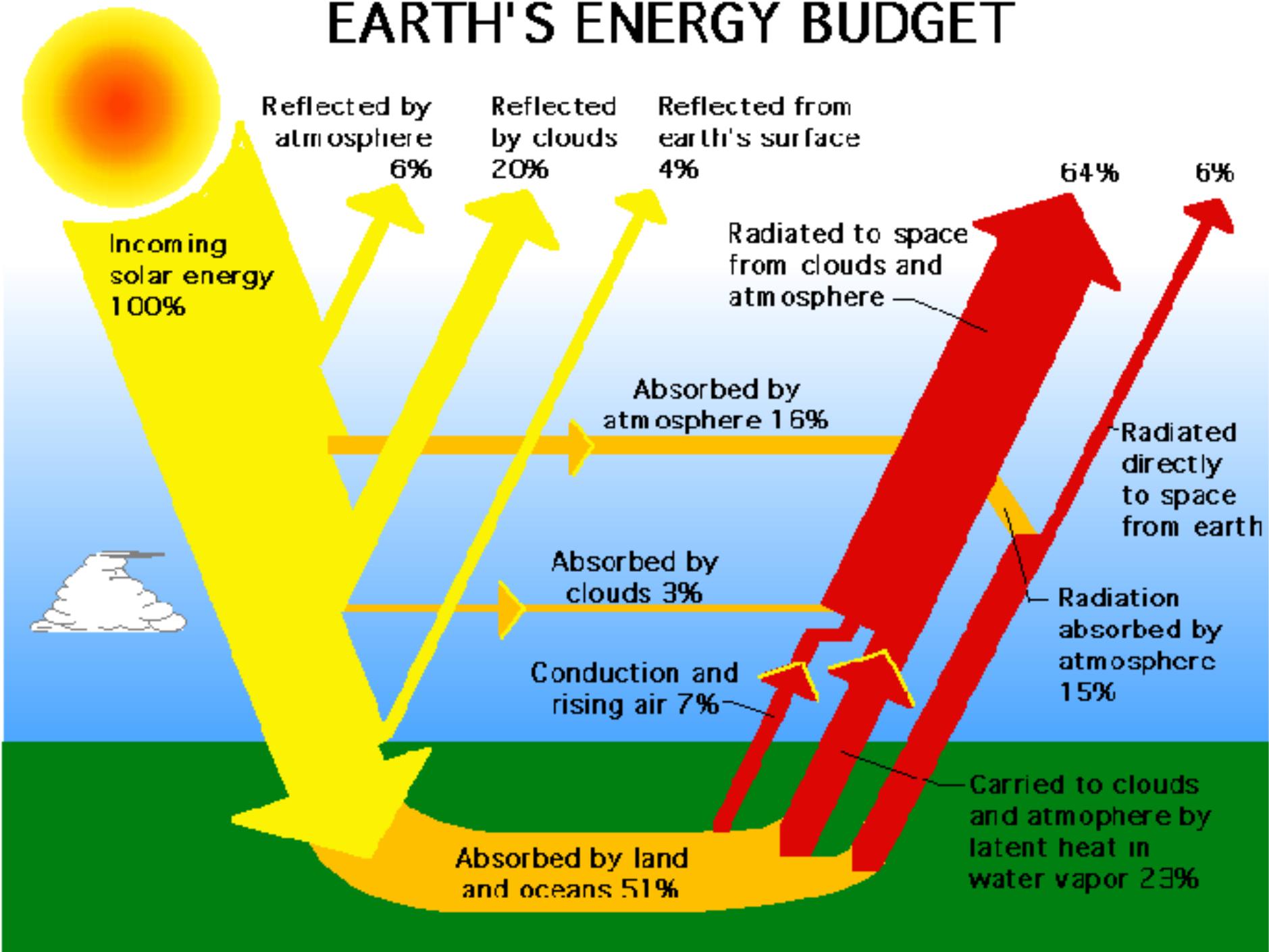
Wavelength
(metres)

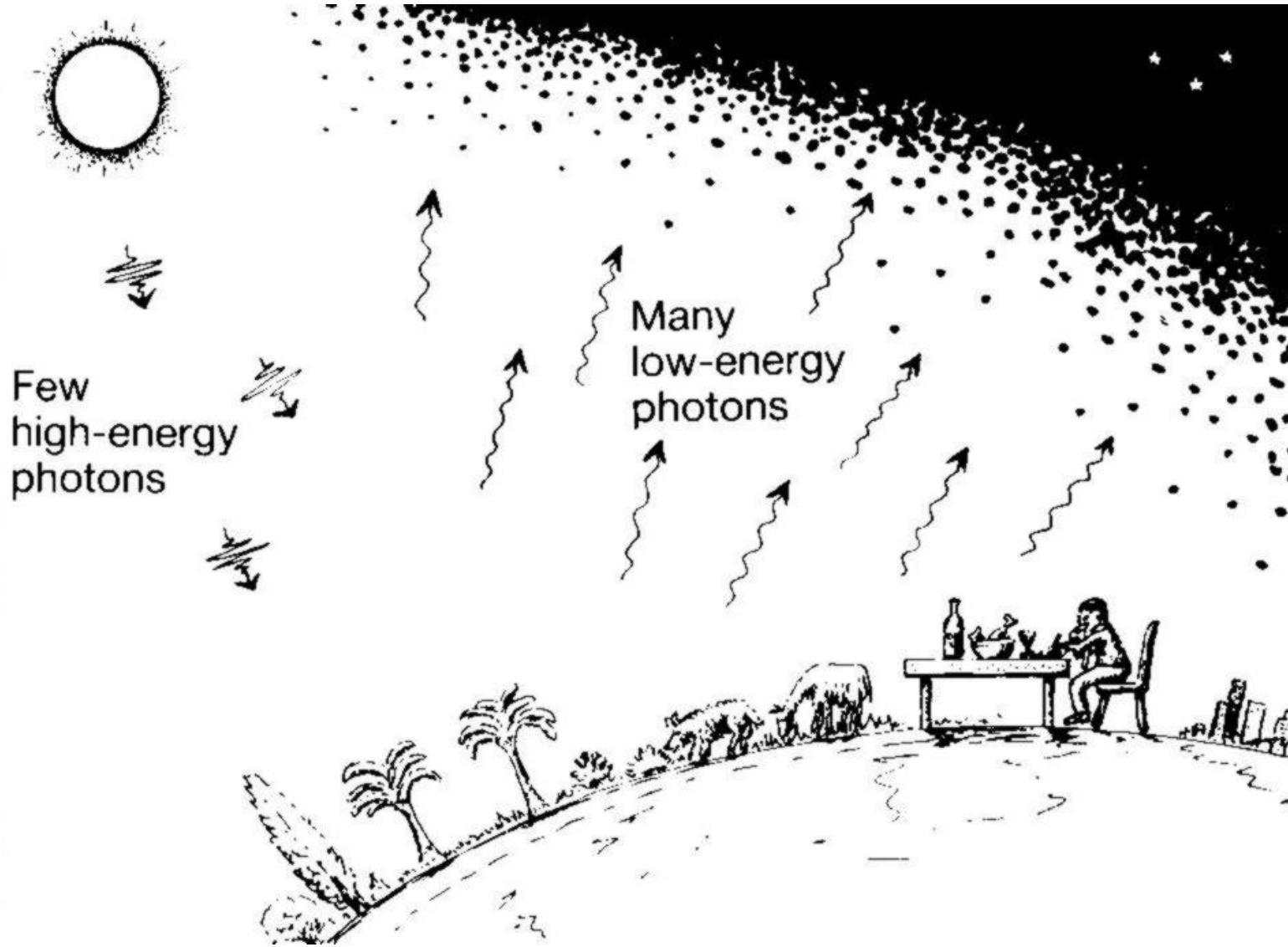


Frequency
(Hz)

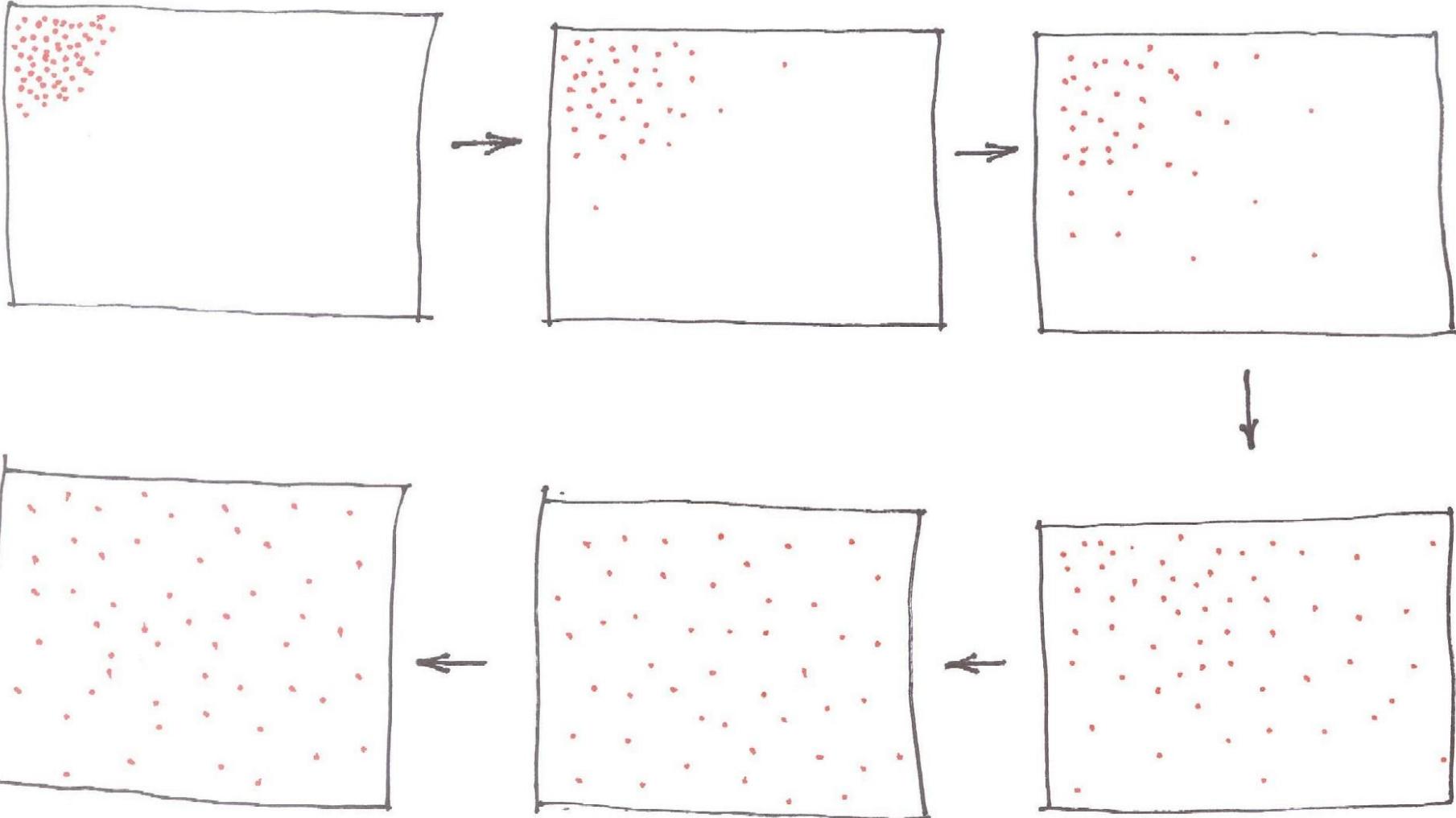


EARTH'S ENERGY BUDGET





From *The Emperor's New Mind* by Roger Penrose



雖然微觀分子的碰撞(運動)是可逆的反應

倒過來的過程並**非**絕對不可能，只是**極不容易發生**，譬如說，幾千萬年內也不會發生

關鍵是一開始的狀態是比較**有秩序**的狀態

事務總是從**有序**的狀態演變成**無序**的狀態

熵 Entropy

$$S = k_B \ln \Omega$$

Ω = number of states accessible to the system

在固定能量下，系統可以具有的狀態的數目

例如 $S \sim N k_B \ln V$

熵大致上代表了「混亂」的情況（混亂的情況越高就越無法預測）

熱力學第二定律：

對於封閉的系統來說，

$$\Delta S \geq 0$$

例如氣體的自由膨脹現象

如果要回復原來(熵較低，或者說較有秩序)的狀態，我們必須先對系統做功，然後將溫度降低。

生命是有秩序的現象

能量有各種形態(例如電磁能、重力位能、粒子的動能等等)

宇宙中的總能量是守恆的，也就是說，
總能量是不會隨時間而變的固定值。

(熱力學第一定律)

所以我們無法「浪費」能量。

「有用」的能量？

一個物體的溫度代表「從其獲得能量的容易程度」

將不同溫度的兩個物體擺在一起，能量會從溫度高的物體流向溫度低的物體，直到兩者的溫度相同。

$$F = E - TS$$

自由能 free energy

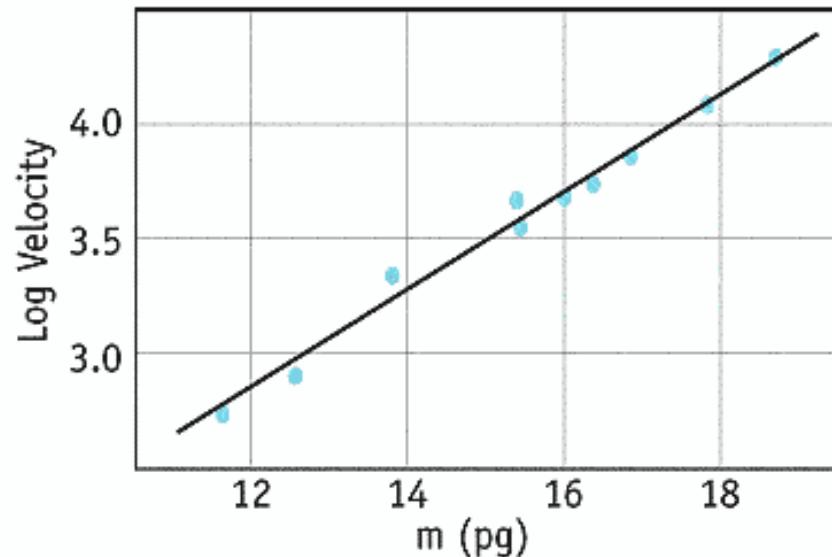
DISCOVERY OF EXPANDING UNIVERSE



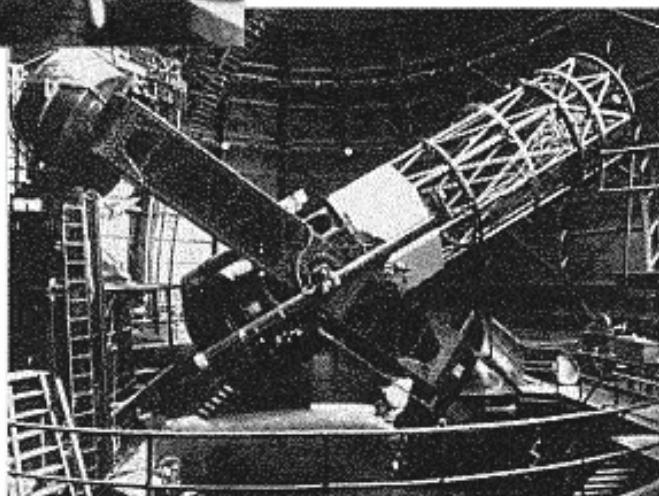
Edwin Hubble

哈伯

(1920's~1930's)



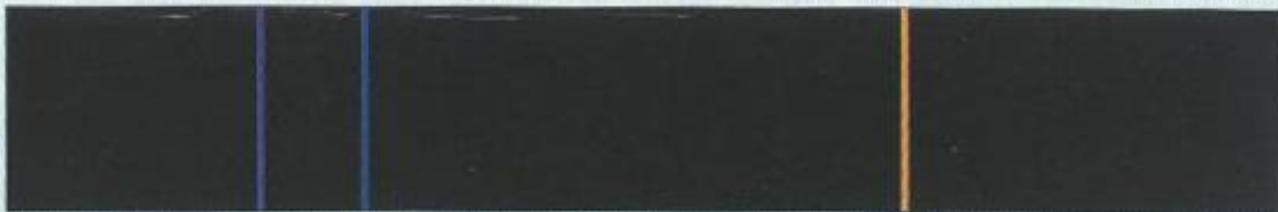
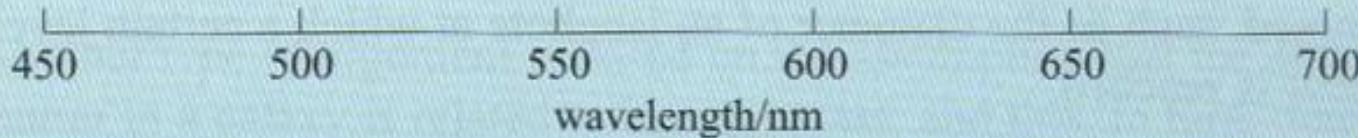
宇宙膨脹



Mt. Wilson
100 Inch
Telescope

發現宇宙膨脹

<http://map.gsfc.nasa.gov/>

 λ_{em}  λ_{obs} 

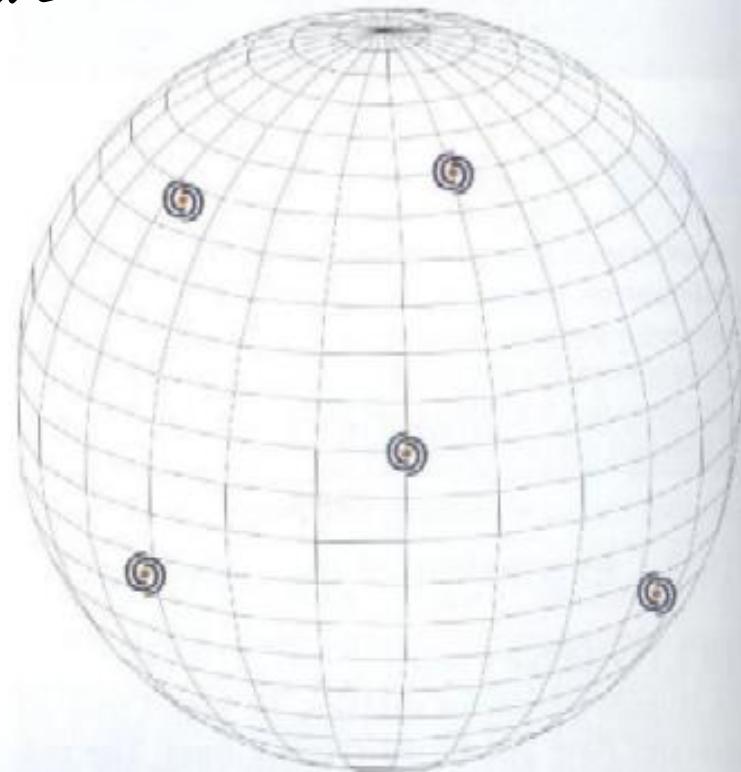
都普勒效應 (Doppler effect)

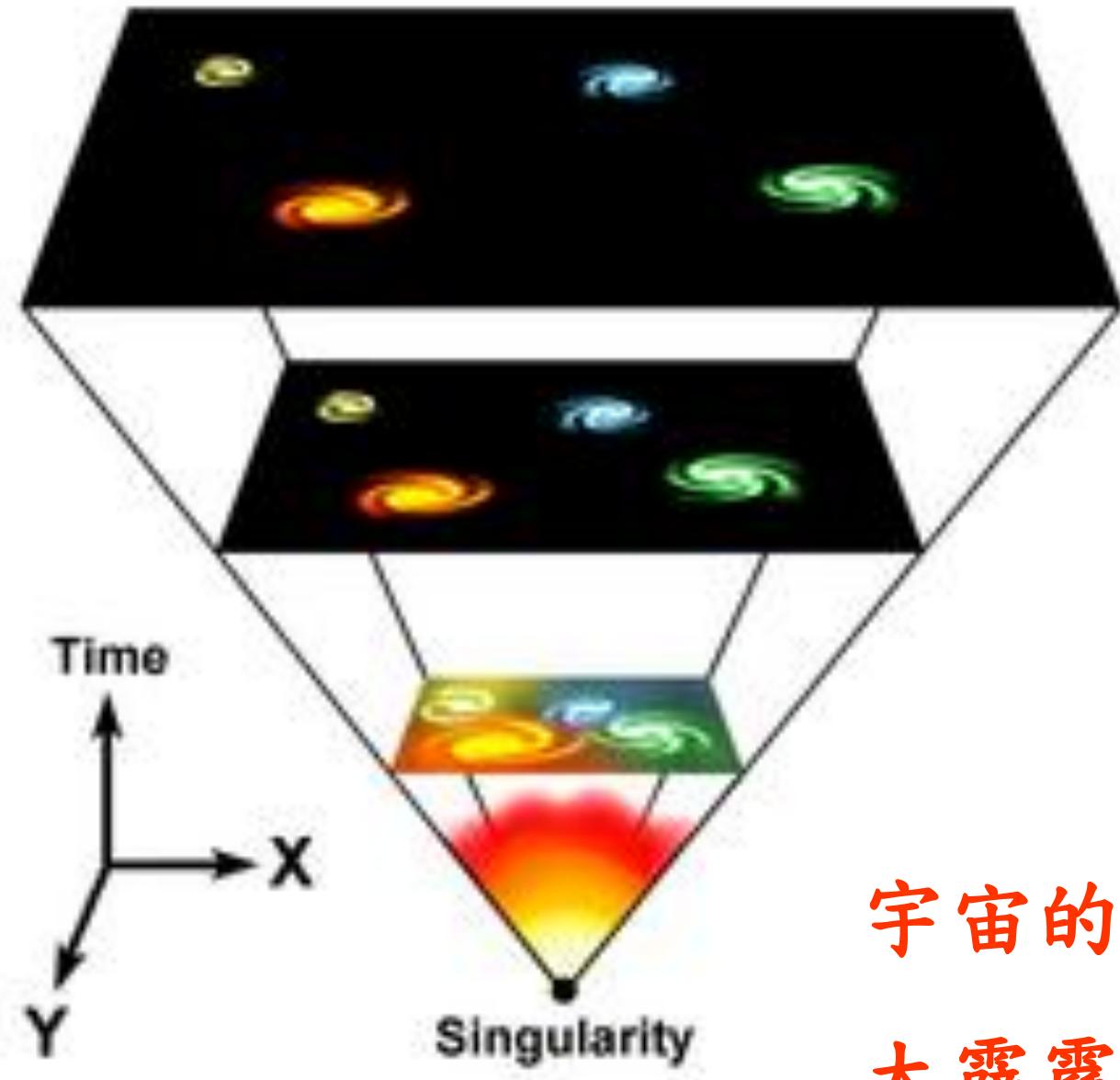
波原遠離 波長變長

波原接近 波長變短



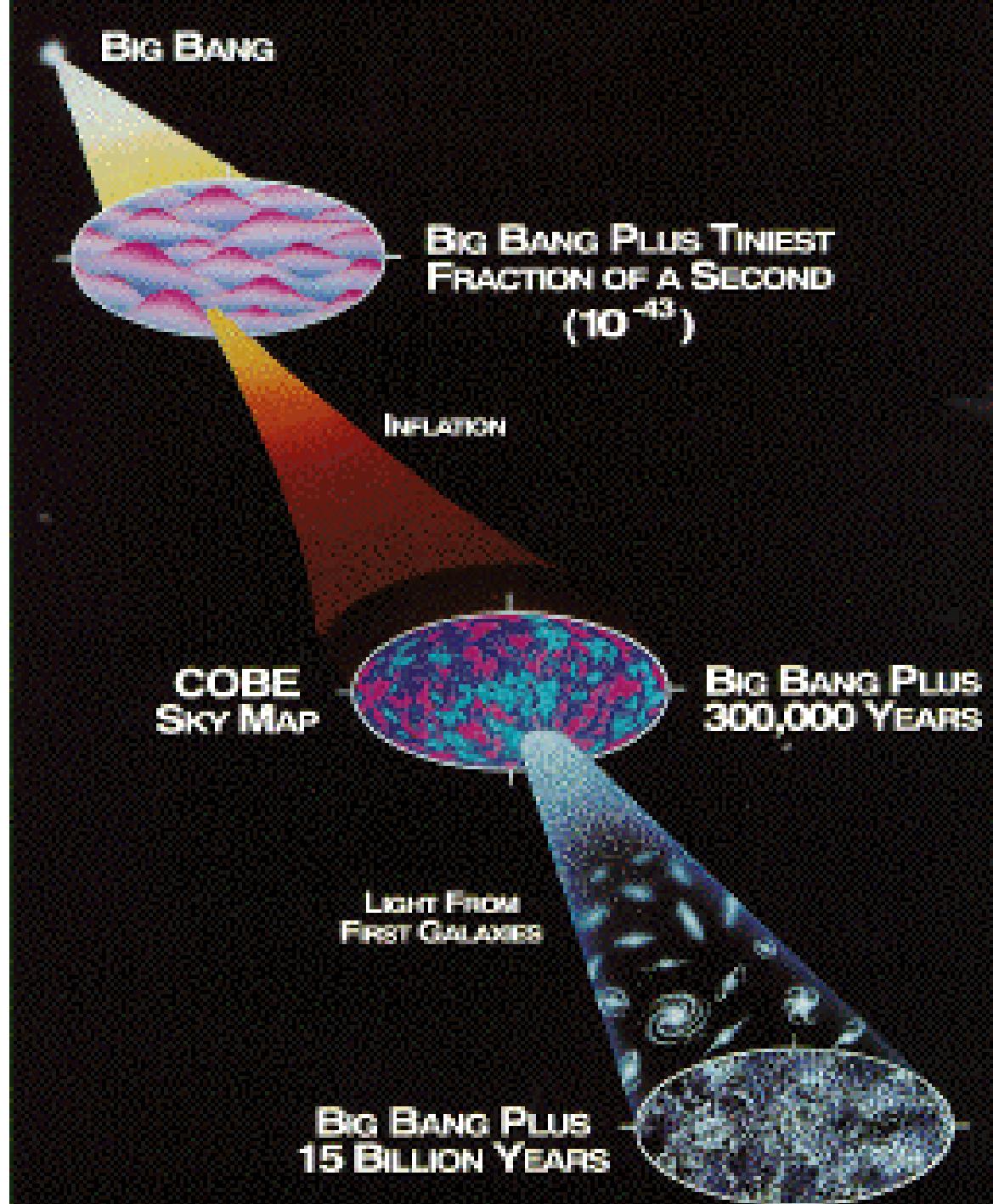
宇宙持續在膨脹



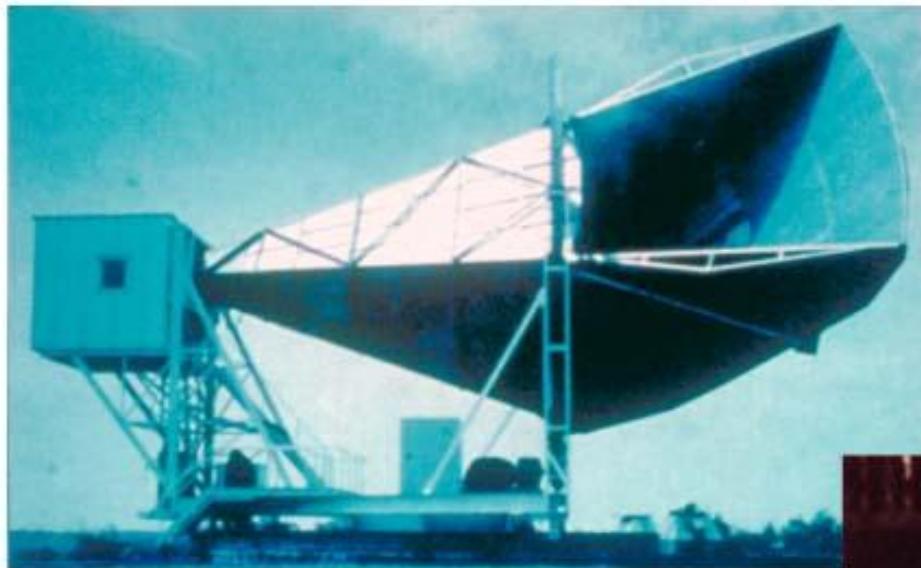


宇宙的起源
大霹靂

大霹靂
約150
億年前



DISCOVERY OF COSMIC BACKGROUND



Microwave Receiver

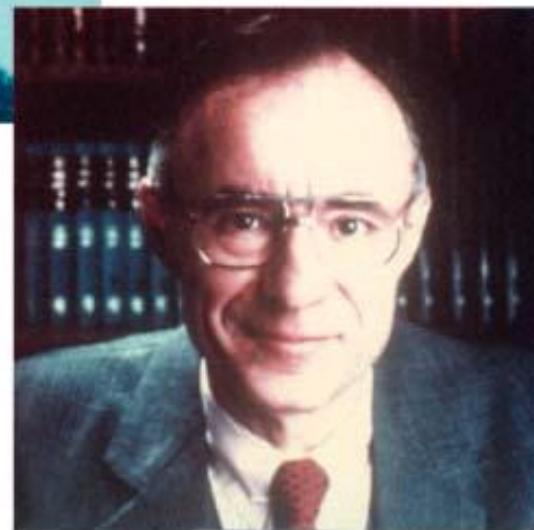


MAP990045

Robert Wilson

宇宙背景輻射

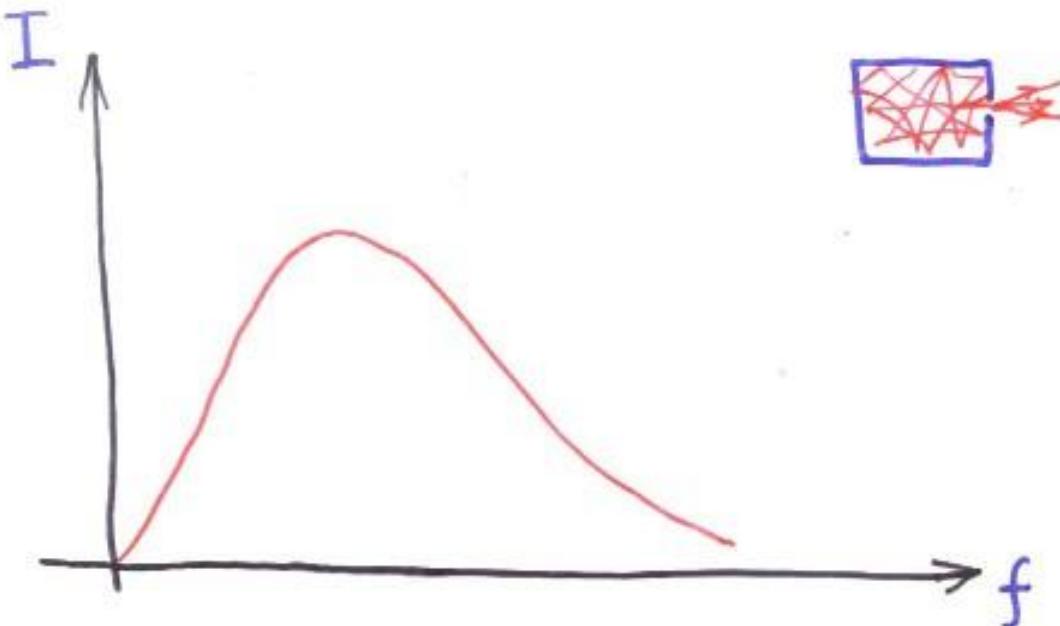
測量7.35cm 微波的強度



Arno Penzias

<http://map.gsfc.nasa.gov/>

黑體輻射



普朗克 1900

能量是不連續的

$$E = n \cdot h f$$

愛因斯坦 1905

光子

$$E_{\text{光子}} = h \cdot f$$



普朗克 M. Planck

1858-1947

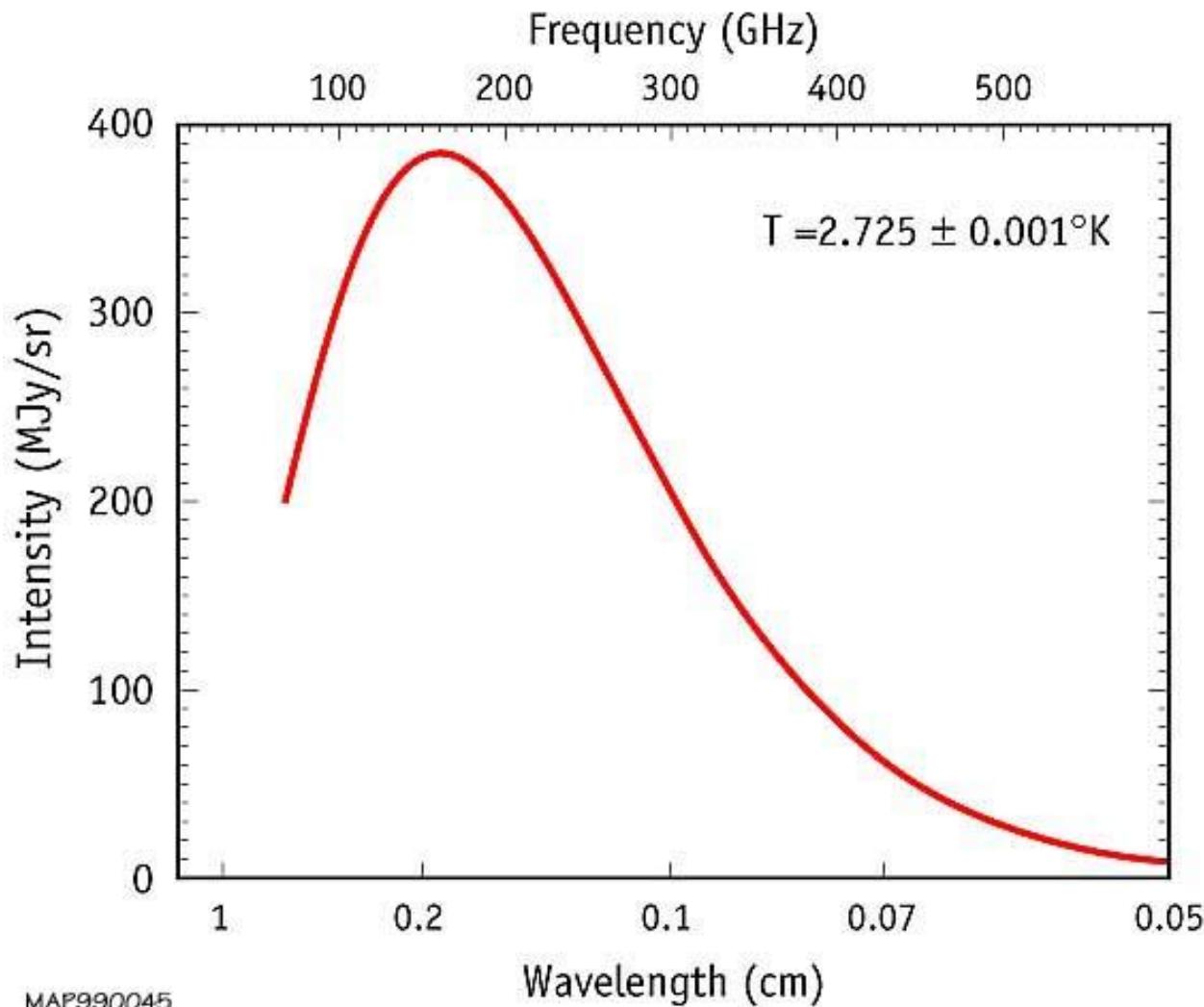


愛因斯坦 A. Einstein

1879-1955

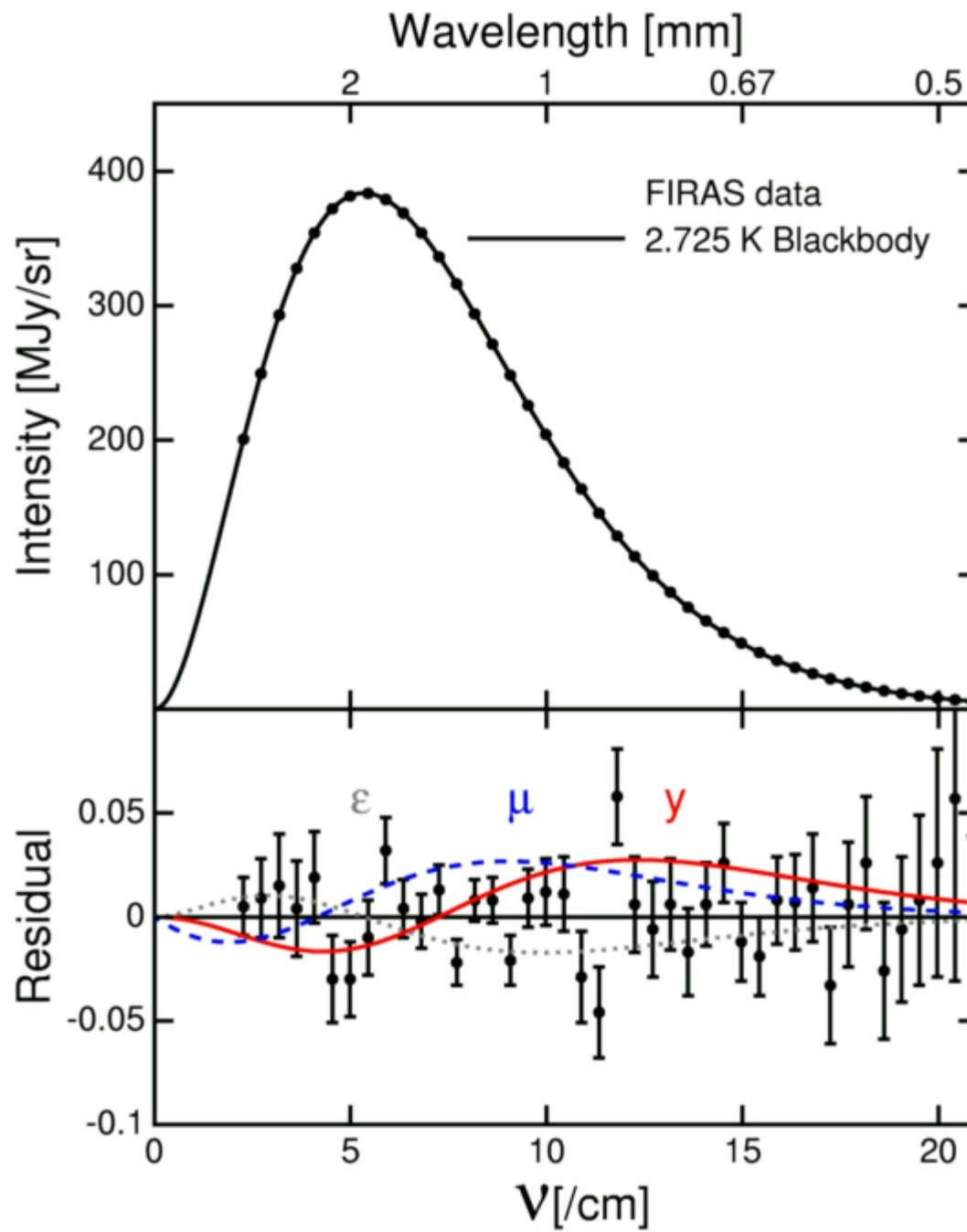
光量子的概念

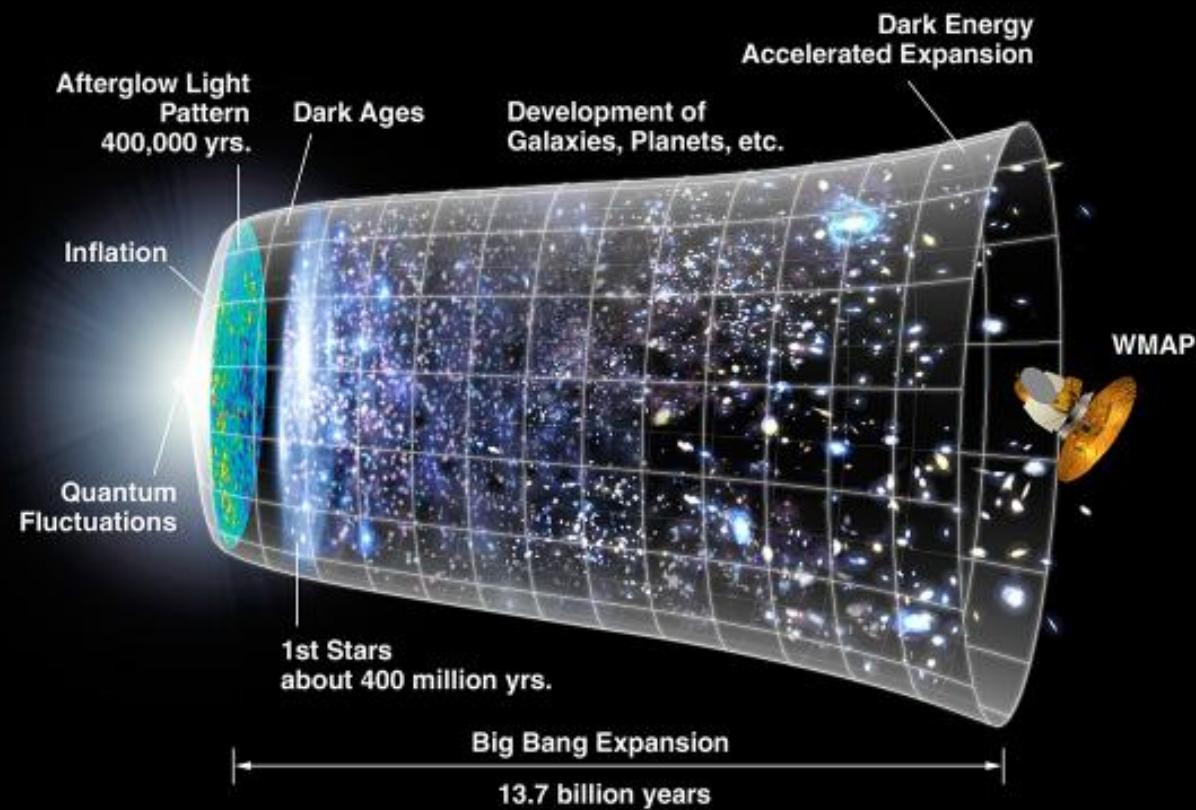
SPECTRUM OF THE COSMIC MICROWAVE BACKGROUND



MAP990045

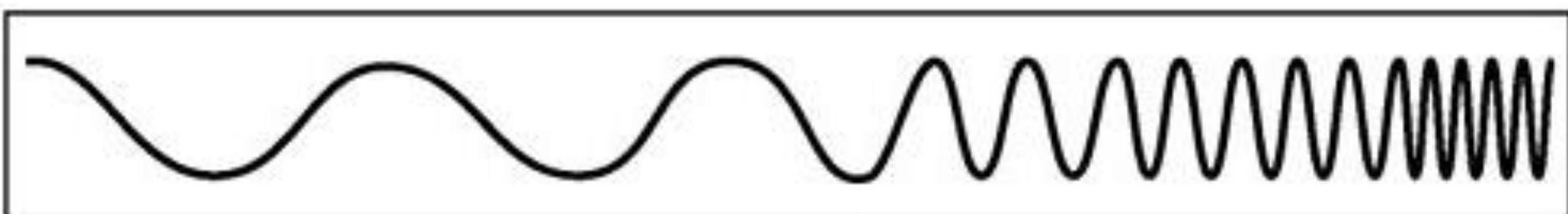
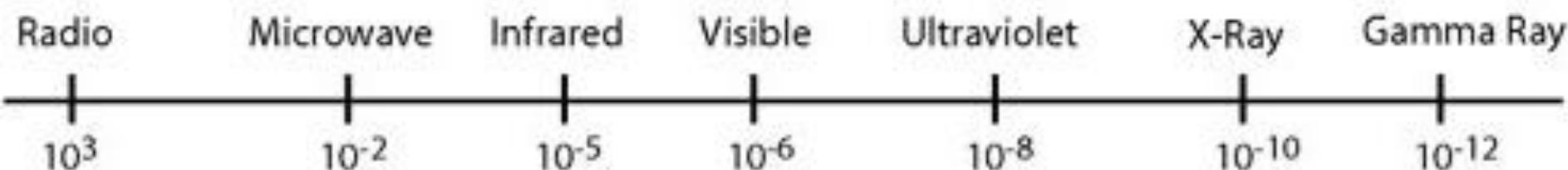
<http://map.gsfc.nasa.gov/>



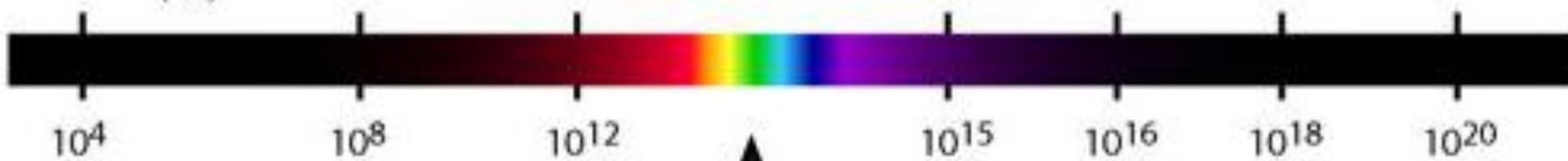


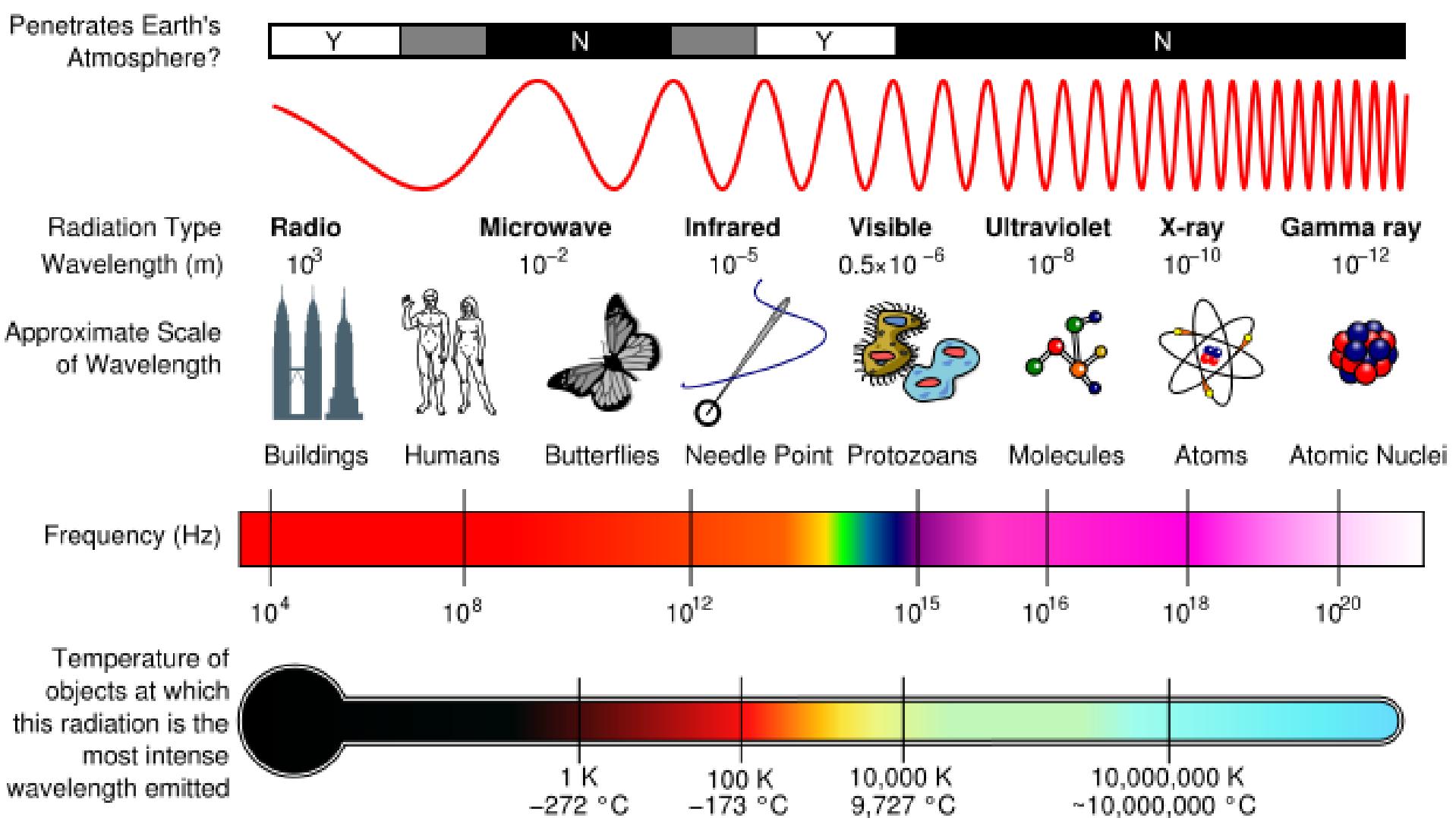
THE ELECTRO MAGNETIC SPECTRUM

Wavelength
(metres)



Frequency
(Hz)





CLASS	FREQUENCY	WAVELENGTH	ENERGY
Y	300 EHz	1 pm	1.24 MeV
HX	30 EHz	10 pm	124 keV
SX	3 EHz	100 pm	12.4 keV
EUV	30 PHz	1 nm	1.24 keV
NUV	3 PHz	10 nm	124 eV
NIR	300 THz	1 nm	1.24 eV
MIR	30 THz	10 nm	124 meV
FIR	3 THz	100 nm	12.4 meV
EHF	300 GHz	1 μm	1.24 meV
SHF	30 GHz	10 μm	124 μeV
UHF	3 GHz	100 μm	12.4 μeV
VHF	300 MHz	1 mm	1.24 μeV
HF	30 MHz	1 cm	124 neV
MF	3 MHz	10 cm	12.4 neV
LF	300 kHz	1 dm	1.24 neV
VLF	30 kHz	10 dm	124 peV
VF/ULF	3 kHz	100 dm	12.4 peV
SLF	300 Hz	1 Mm	1.24 peV
ELF	30 Hz	10 Mm	124 feV
	3 Hz	100 Mm	12.4 feV

Legend^{[2][3][4]}

γ = Gamma rays

HX= Hard X-rays

SX= Soft X-rays

EUV= Extreme ultraviolet

NUV= Near ultraviolet

Visible light

NIR= Near Infrared

MIR= Mid infrared

FIR= Far infrared

Radio waves

EHF= Extremely high freq.

SHF= Super high freq.

UHF= Ultra high freq.

VHF= Very high freq.

HF= High freq.

MF= Medium freq.

LF= Low freq.

VLF= Very low freq.

VF/ULF= Voice freq.

SLF= Super low freq.

ELF= Extremely low freq.

Freq=Frequency

Submultiples

Value	Symbol	Name
10^{-1} W	dW	deciwatt
10^{-2} W	cW	centiwatt
10^{-3} W	mW	milliwatt
10^{-6} W	μW	microwatt
10^{-9} W	nW	nanowatt
10^{-12} W	pW	picowatt
10^{-15} W	fW	femtowatt
10^{-18} W	aW	attowatt
10^{-21} W	zW	zeptowatt
10^{-24} W	yW	yoctowatt

Multiples

Value	Symbol	Name
10^1 W	daW	decawatt
10^2 W	hW	hectowatt
10^3 W	kW	kilowatt
10^6 W	MW	megawatt
10^9 W	GW	gigawatt
10^{12} W	TW	terawatt
10^{15} W	PW	petawatt
10^{18} W	EW	exawatt
10^{21} W	ZW	zettawatt
10^{24} W	YW	yottawatt

Common multiples are in **bold** face

U.S. nuclear power plants have net summer capacities between about 500 and 1300 MW.

Microjoule

The [Large Hadron Collider](#) (LHC) is expected to produce collisions on the order of 1 microjoule (7 [TeV](#)) per particle.

Kilojoule

The kilojoule (kJ) is equal to one thousand joules. [Food labels](#) in some countries express [food energy](#) in kilojoules. One kilojoule is about the amount of [solar radiation](#) received by one square metre of the [Earth](#) in one second.

Megajoule

The megajoule (MJ) is equal to one million joules, or approximately the kinetic energy of a one-ton vehicle moving at 160 km/h (100 mph).

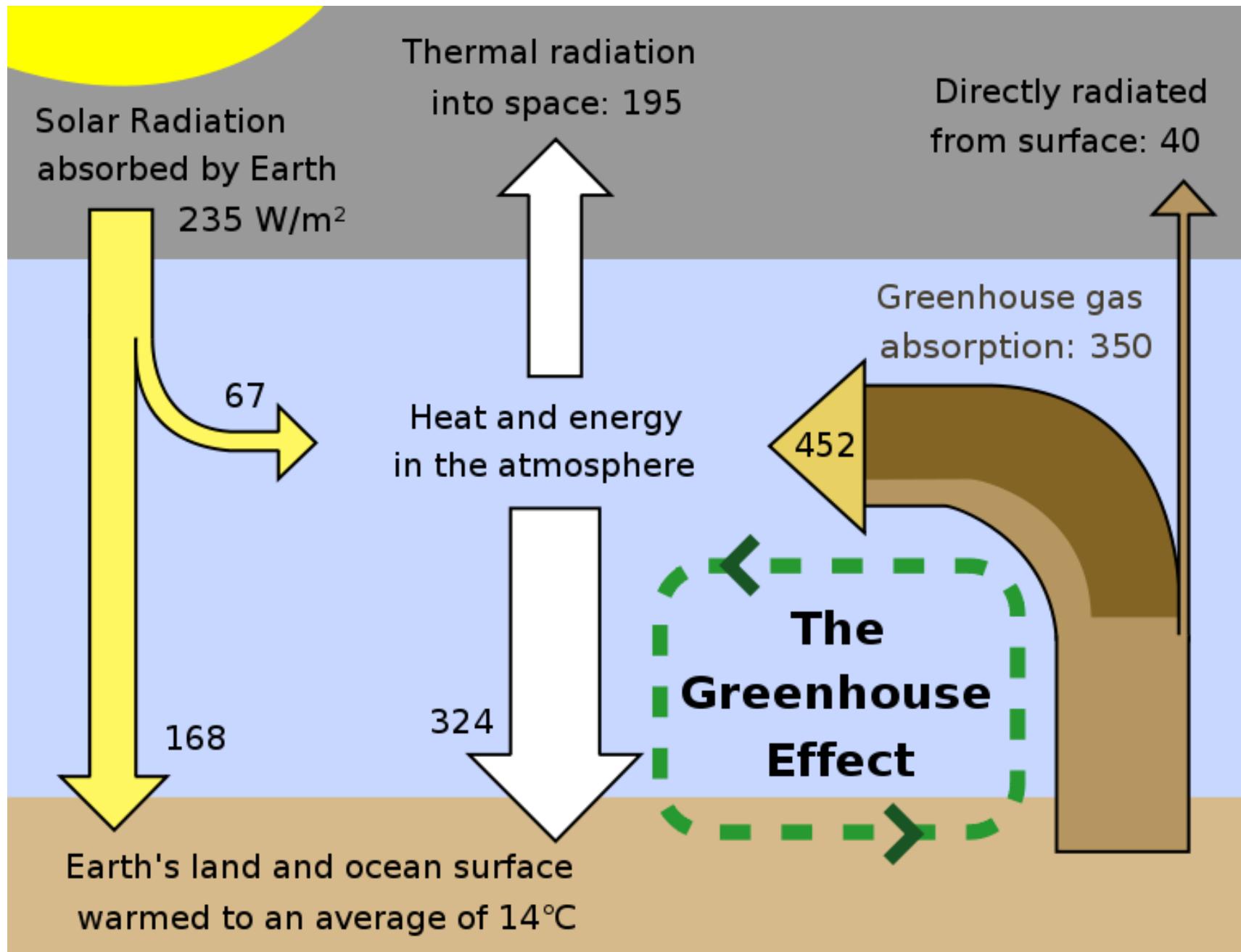
Gigajoule

The gigajoule (GJ) is equal to one billion joules. Six gigajoules is about the amount of [chemical energy](#) in a [barrel](#) of oil.

Terajoule

The terajoule (TJ) is equal to one trillion joules. About 60 terajoules were released by [the bomb that exploded over Hiroshima](#).

In physics, the **electron volt** (symbol eV; also written **electronvolt**) is a unit of energy equal to approximately 1.602×10^{-19} J



The Greenhouse Effect

Some of the infrared radiation passes through the atmosphere but most is absorbed and re-emitted in all directions

by greenhouse gas molecules and clouds.

The effect of this is to warm the Earth's surface and the lower atmosphere.

Solar radiation powers the climate system.

Some solar radiation is reflected by the Earth and the atmosphere.

About half the solar radiation is absorbed by the Earth's surface and warms it.

Infrared radiation is emitted from the Earth's surface.



ATMOSPHERE

EARTH