

ASTROPARTICLES

Messengers of the Universe

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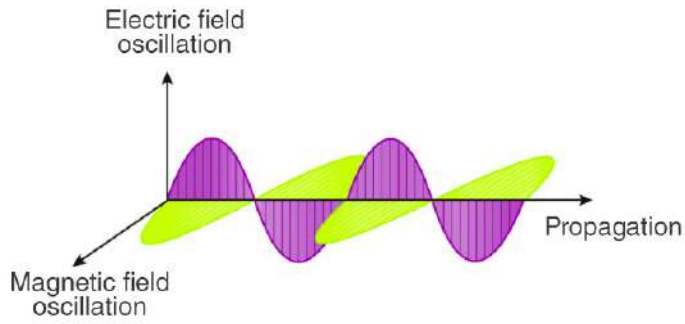
photons

cosmic rays

neutrinos

gravitational waves

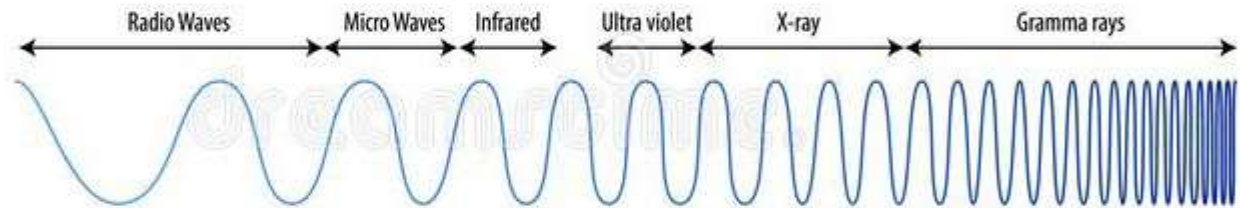
Photons: What are they?



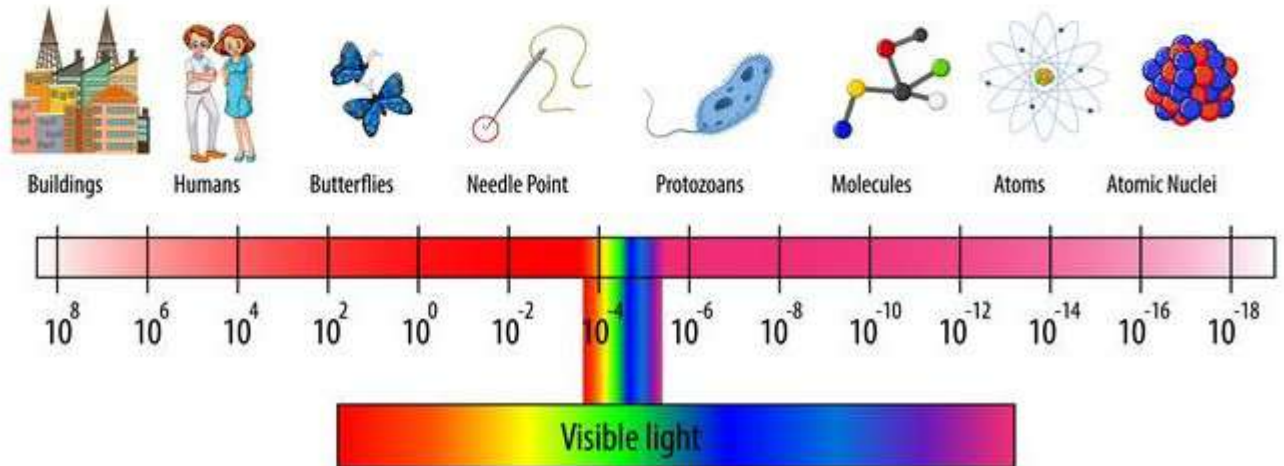
Sources



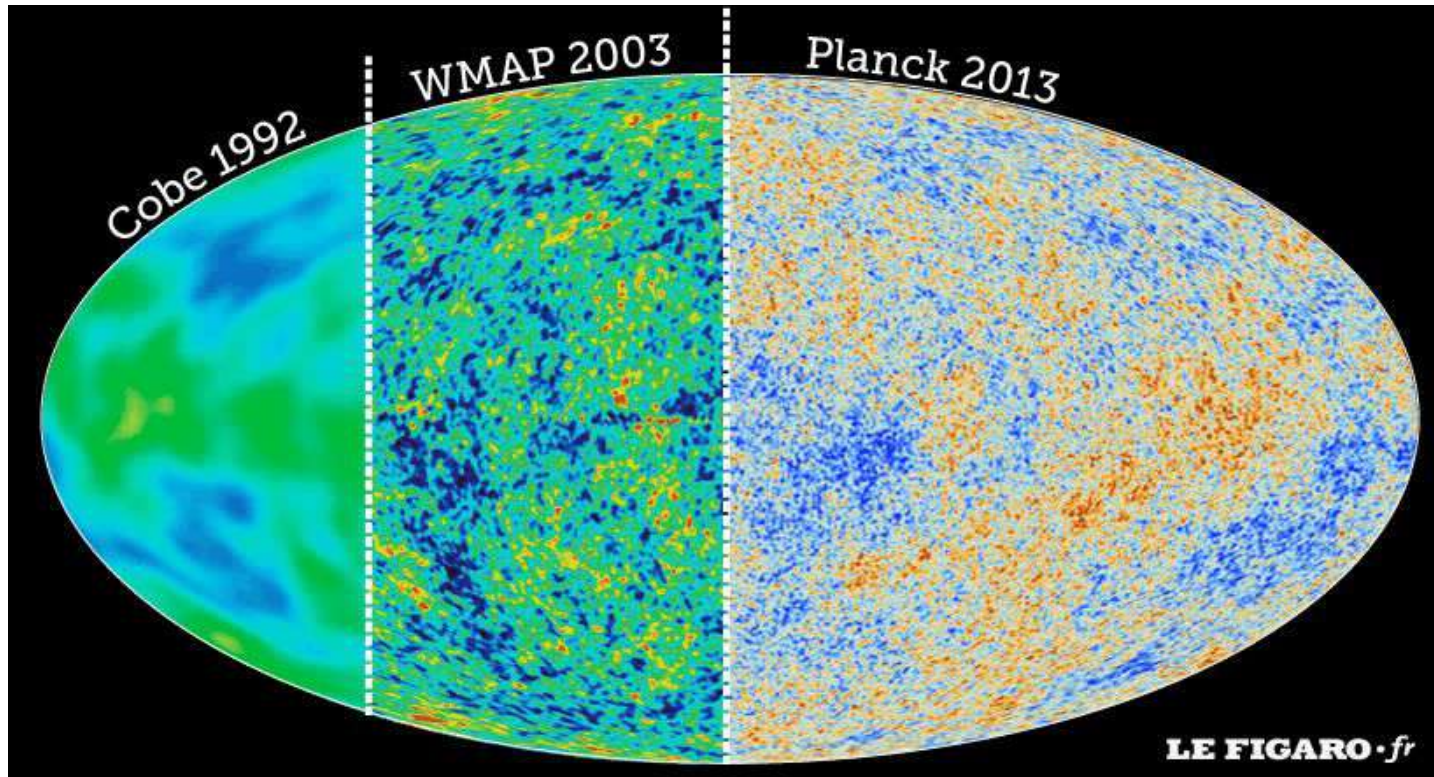
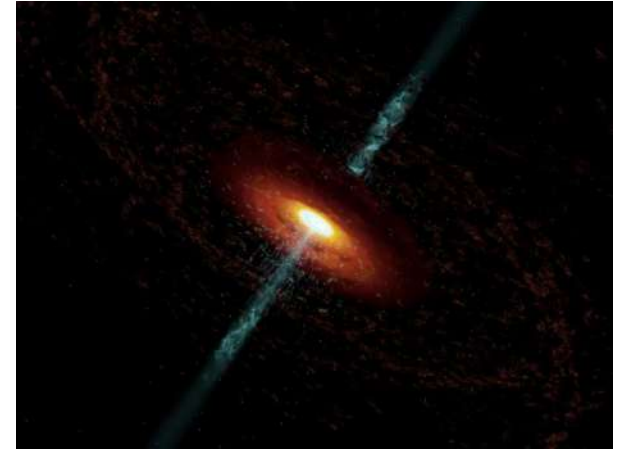
Radiation Type
Wavelength (m)



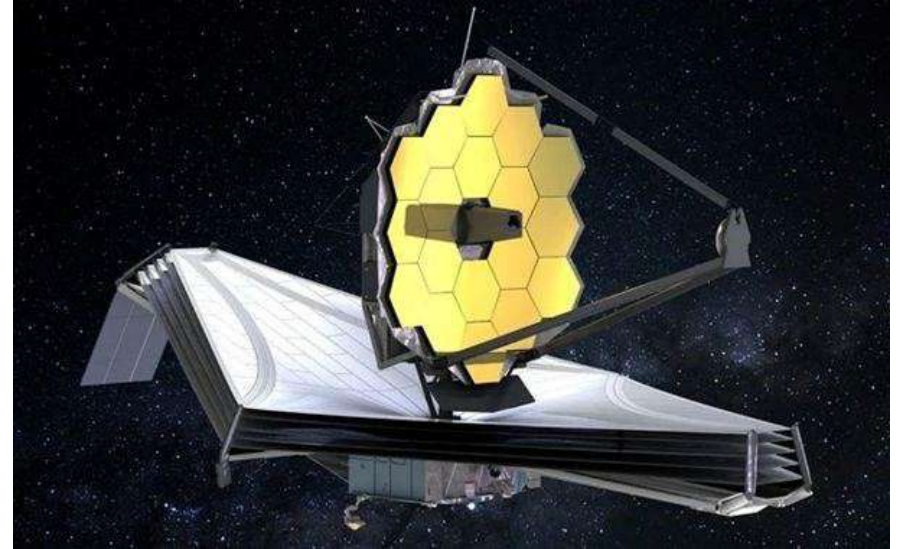
Approximate scale
of wavelength



Photons: Where do they come from?



Photons: How do we detect them?





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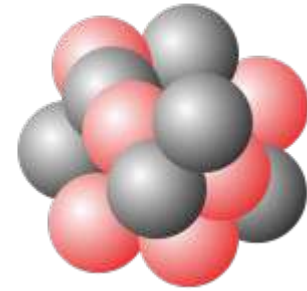
Cosmic rays: What are they?



proton



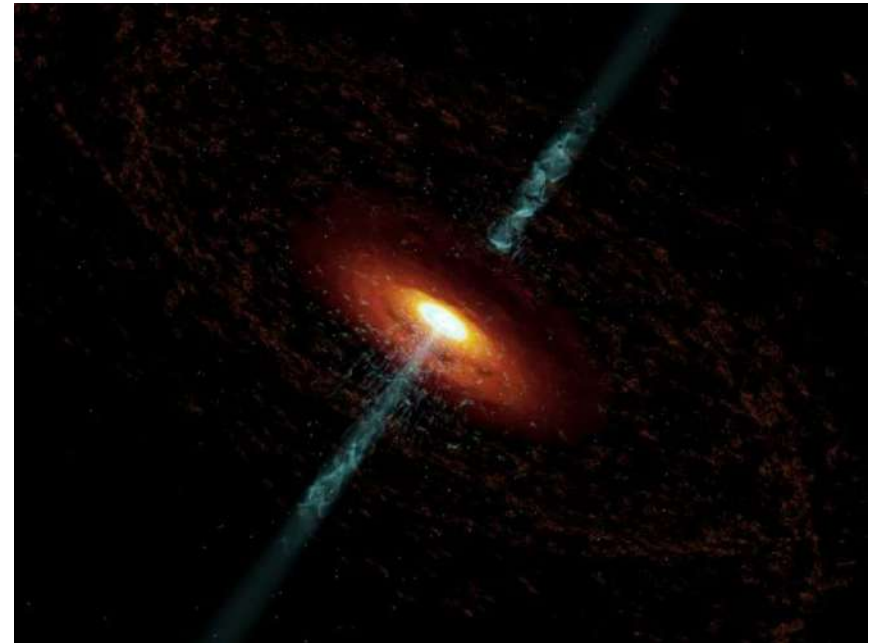
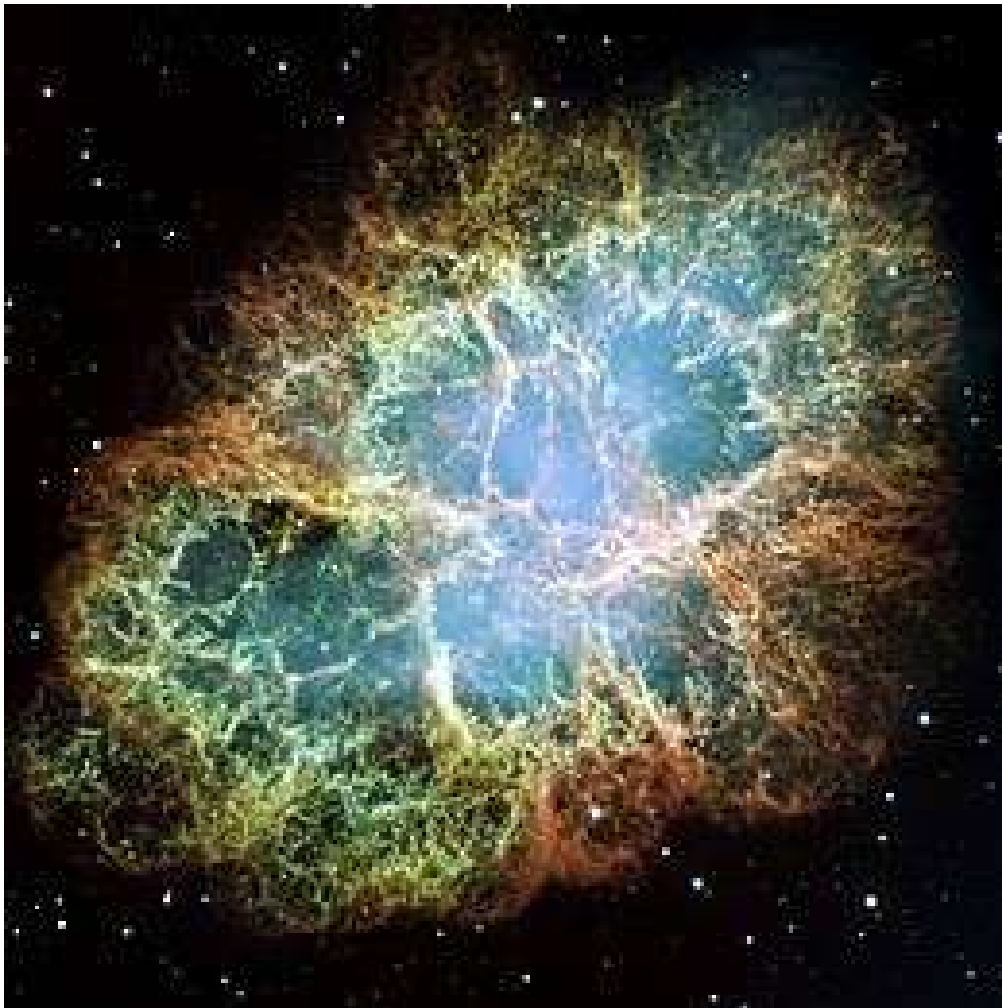
alpha particle



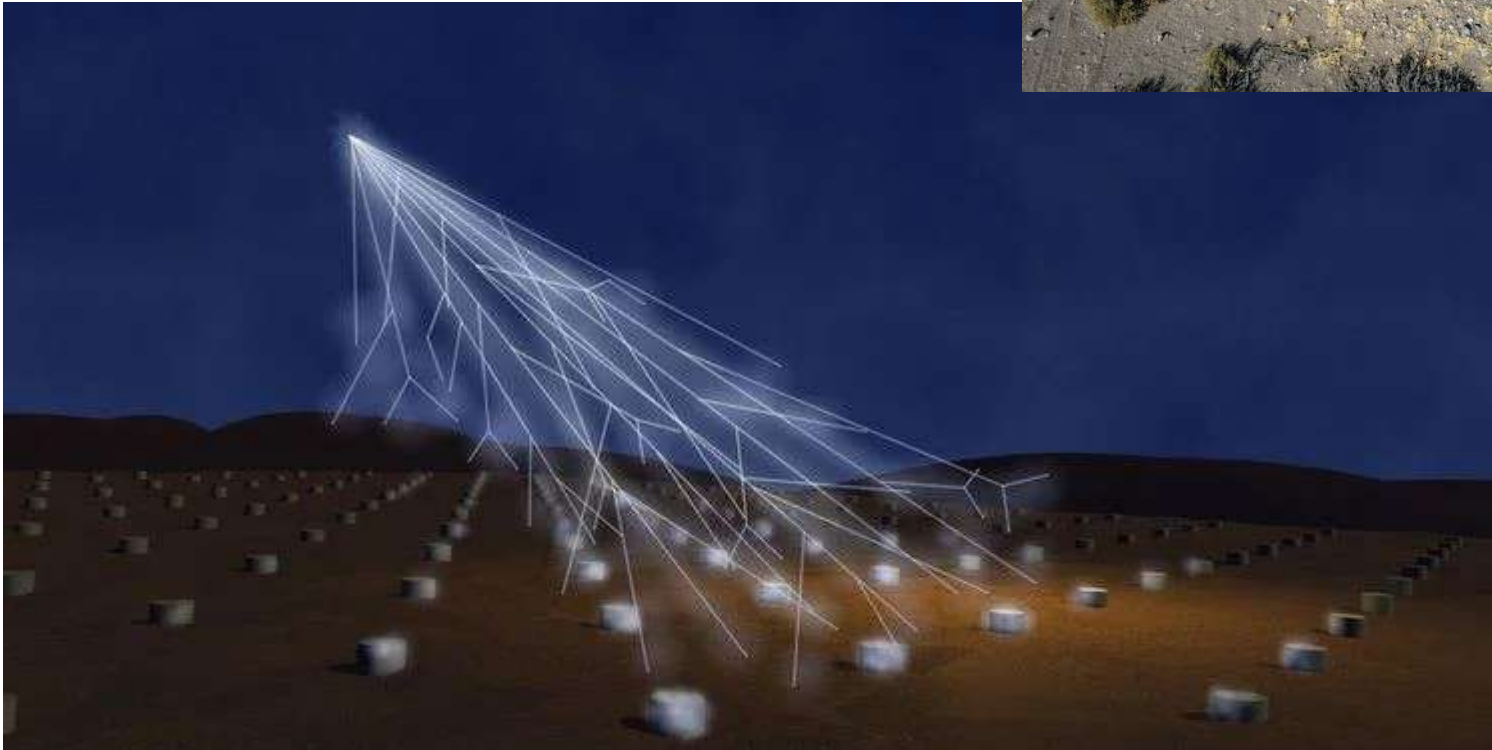
heavy nucleus

„from above”

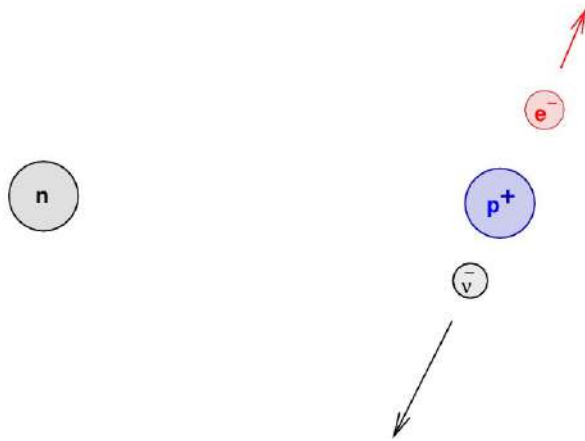
Cosmic rays: Where do they come from?



Cosmic rays: How do we detect them?



Neutrinos: What are they?



Standard Model of Elementary Particles

	three generations of matter (fermions)			interactions / force carriers (bosons)	
	I	II	III		
mass	$\approx 2.2 \text{ MeV}/c^2$	$\approx 1.28 \text{ GeV}/c^2$	$\approx 173.1 \text{ GeV}/c^2$	0	$\approx 124.97 \text{ GeV}/c^2$
charge	$\frac{2}{3}$	$\frac{2}{3}$	$\frac{2}{3}$	0	0
spin	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	1	0
	u up	c charm	t top	g gluon	H higgs
	d down	s strange	b bottom	γ photon	
	e electron	μ muon	τ tau	Z Z boson	
	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	W W boson	

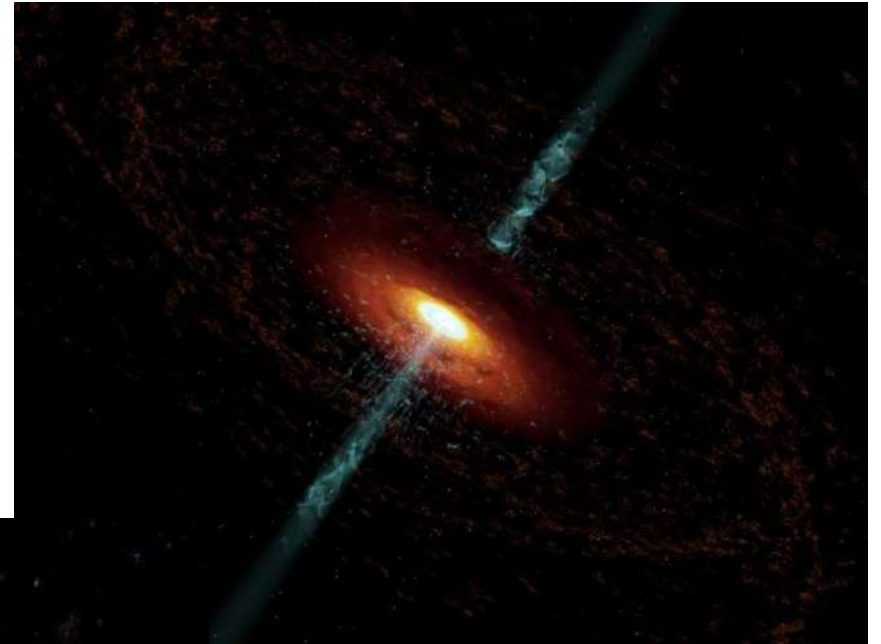
QUARKS (left side label)

LEPTONS (left side label)

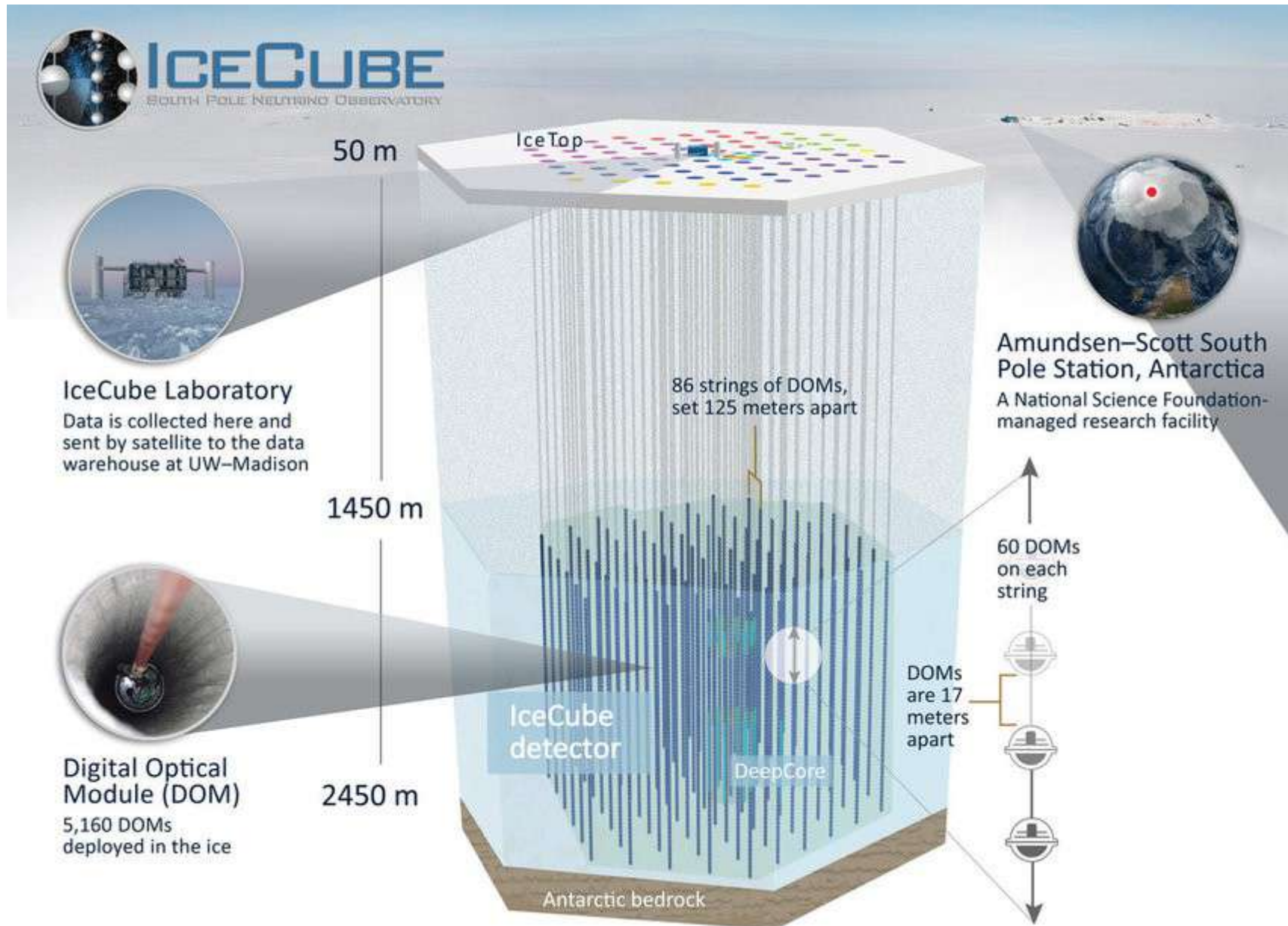
GAUGE BOSONS VECTOR BOSONS (bottom right label)

SCALAR BOSONS (right side label)

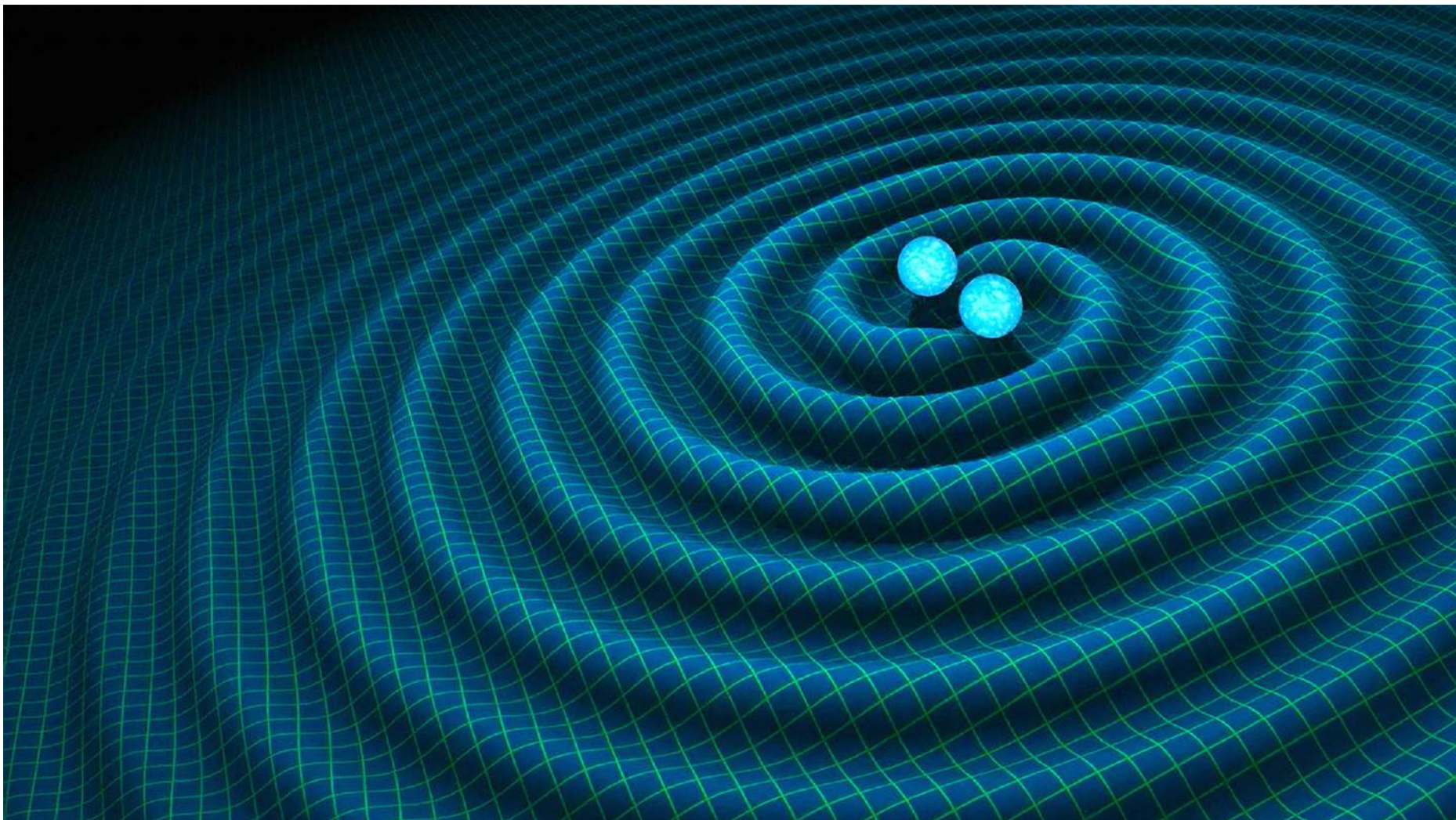
Neutrinos: Where do they come from?



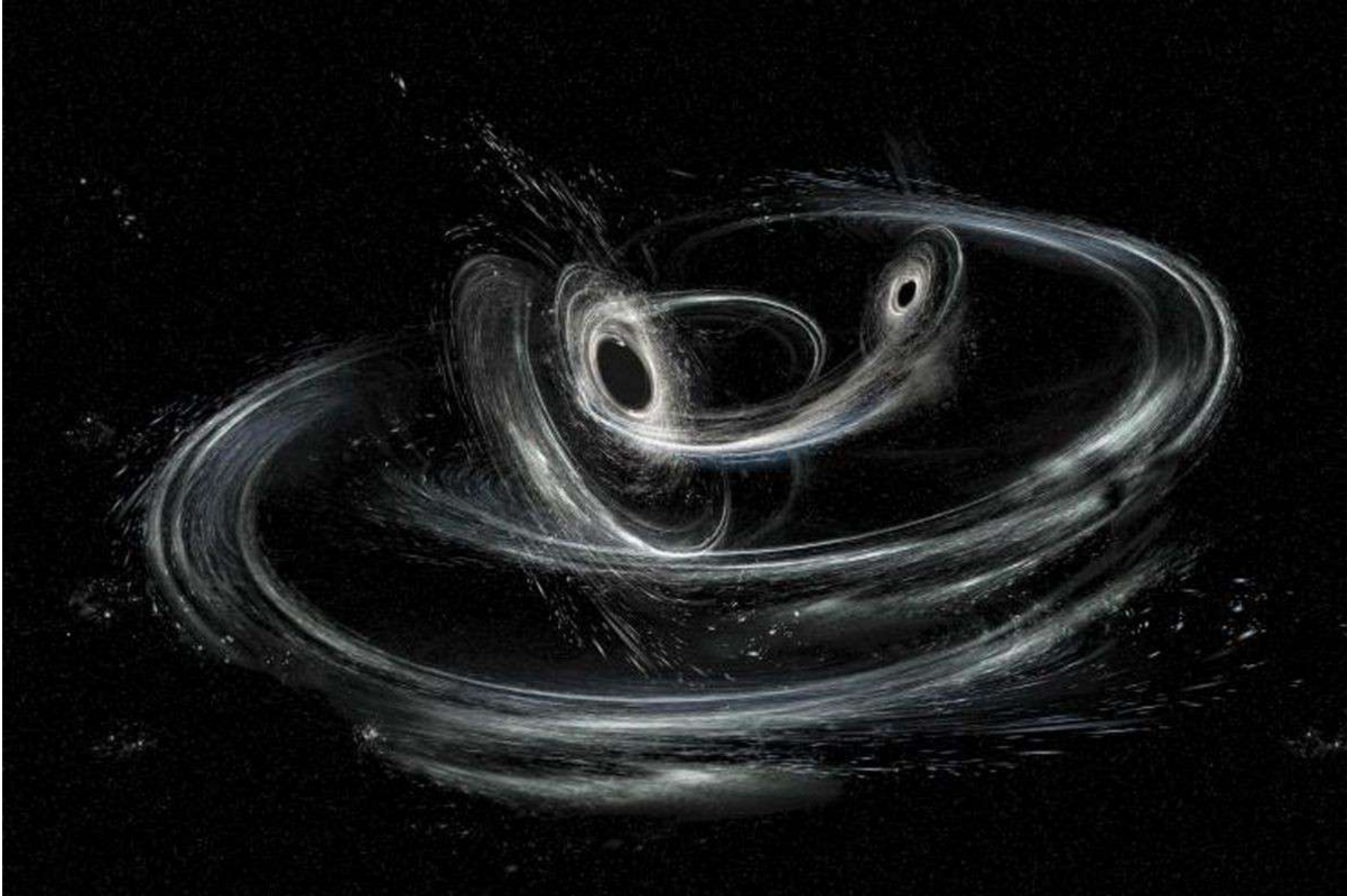
Neutrinos: How do we detect them?



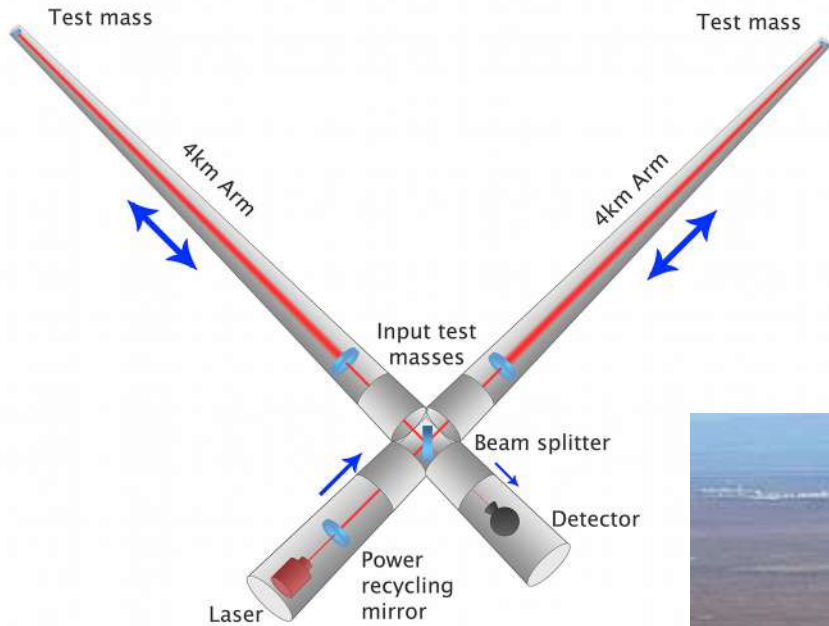
Gravitational waves: What are they?



Gravitational waves: Where do they come from?

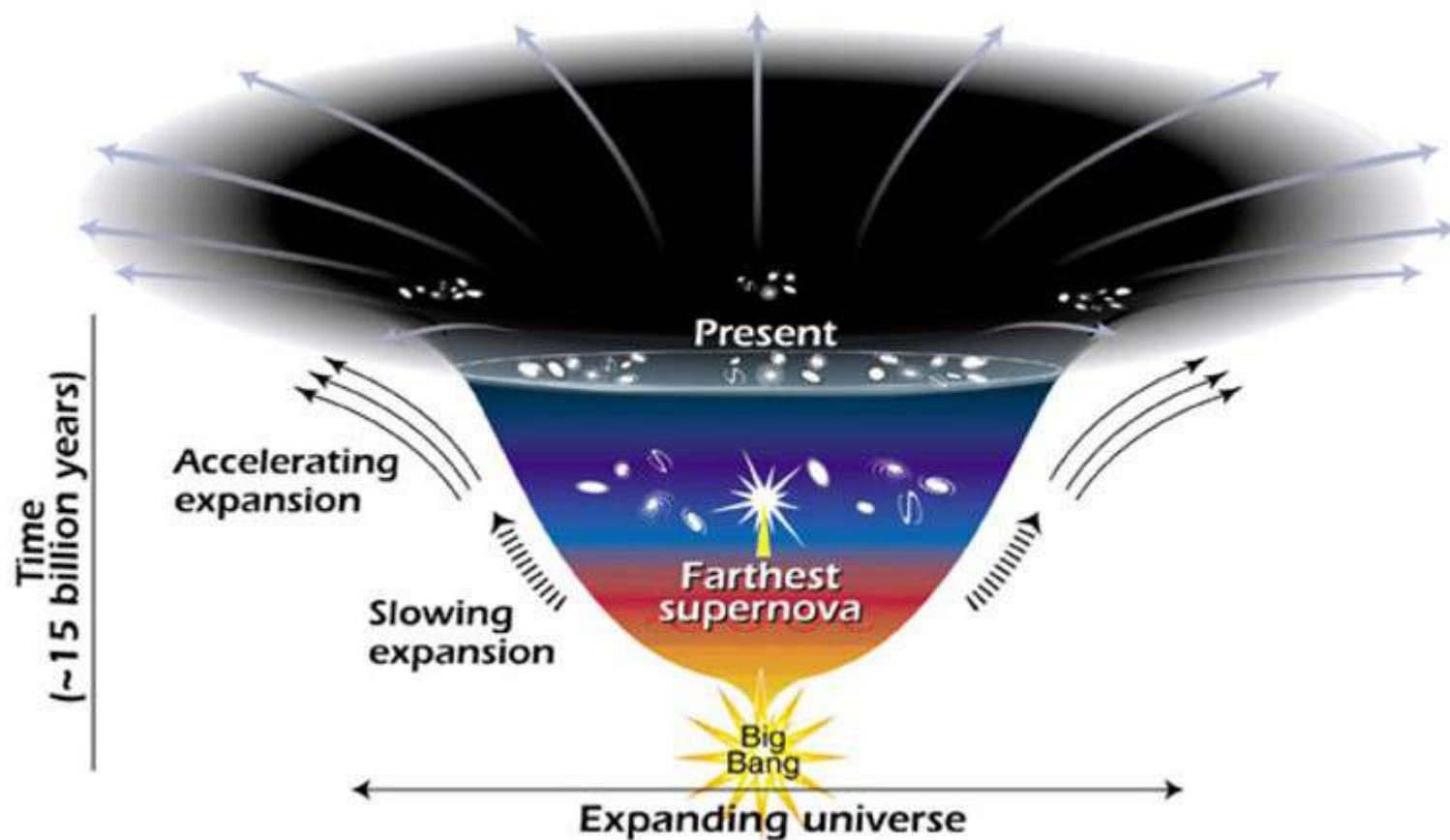


Gravitational waves: How do we detect them?



Some interesting facts

(we have learned from astroparticles)



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(we have learned from astroparticles)

