Neutrino Oscillation: an Avenue to Probe Dark Energy

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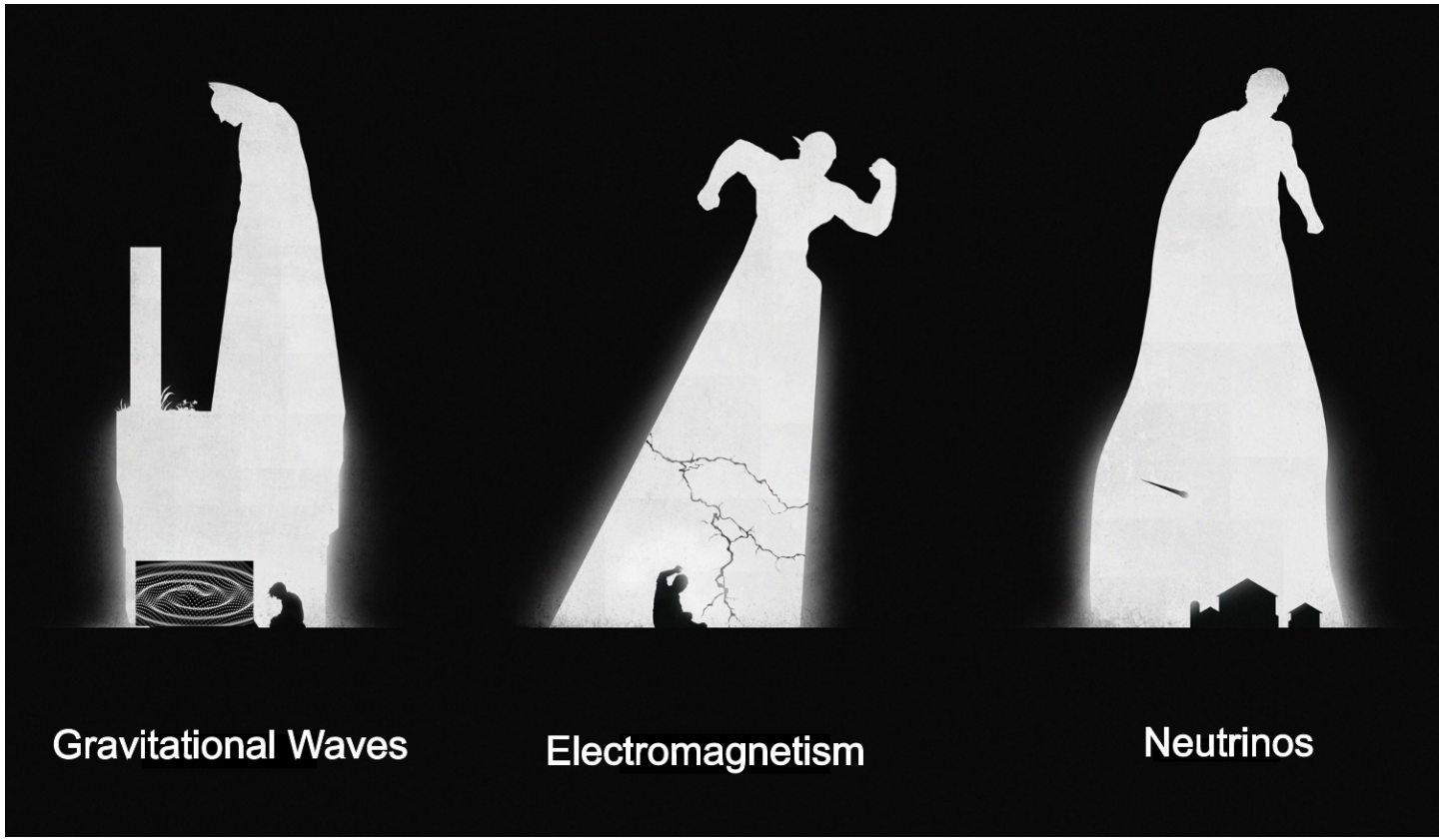
Multimessenger Alliance



Neutrino Oscillation Probability

In Particle Physics(Minkowski spacetime):
$P_{\nu_e \to \nu_\mu} = \sin^2 2\theta \sin^2 \left(\frac{\Delta m^2 L}{4E}\right)$

If simply applied(SA) to Cosmology(FLRW Spacetime):
$L \to d_L, E \to E_0/a(z)$

- $\theta \equiv$ mixing angle;
- $\Delta m^2 \equiv$ mass squared difference;
- $L \equiv$source-observer distance;
- $E \equiv$neutrino energy;
- $d_L \equiv$Luminosity distance;
- $E_0 \equiv$observed neutrino energy;
- $a(z) \equiv$scale factor at redshift z.

Neutrino Oscillation Probability

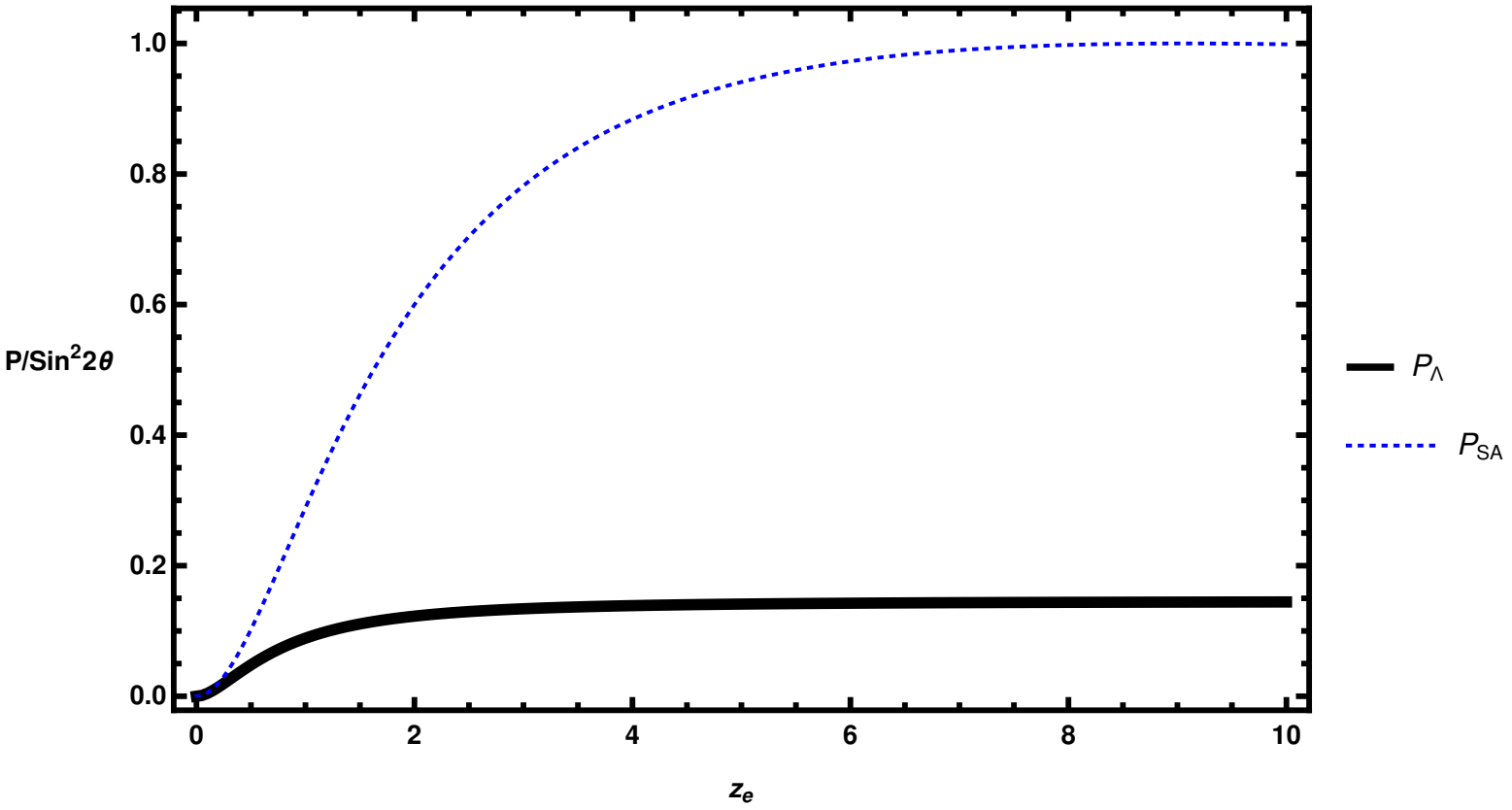
Quantum spinors in flat FLRW universe with cosmological constant DE:

$P_\Lambda = \sin^2 2\theta \sin^2 \omega_\Lambda;$

$$\omega_\Lambda = \frac{\Delta m^2}{2H_0 E_0} \int_0^{z_{\rm em}} \left(\Omega_{m_0}(1+z)^7 + \Omega_{\Lambda_0}(1+z)^4 \right)^{-1/2} dz$$

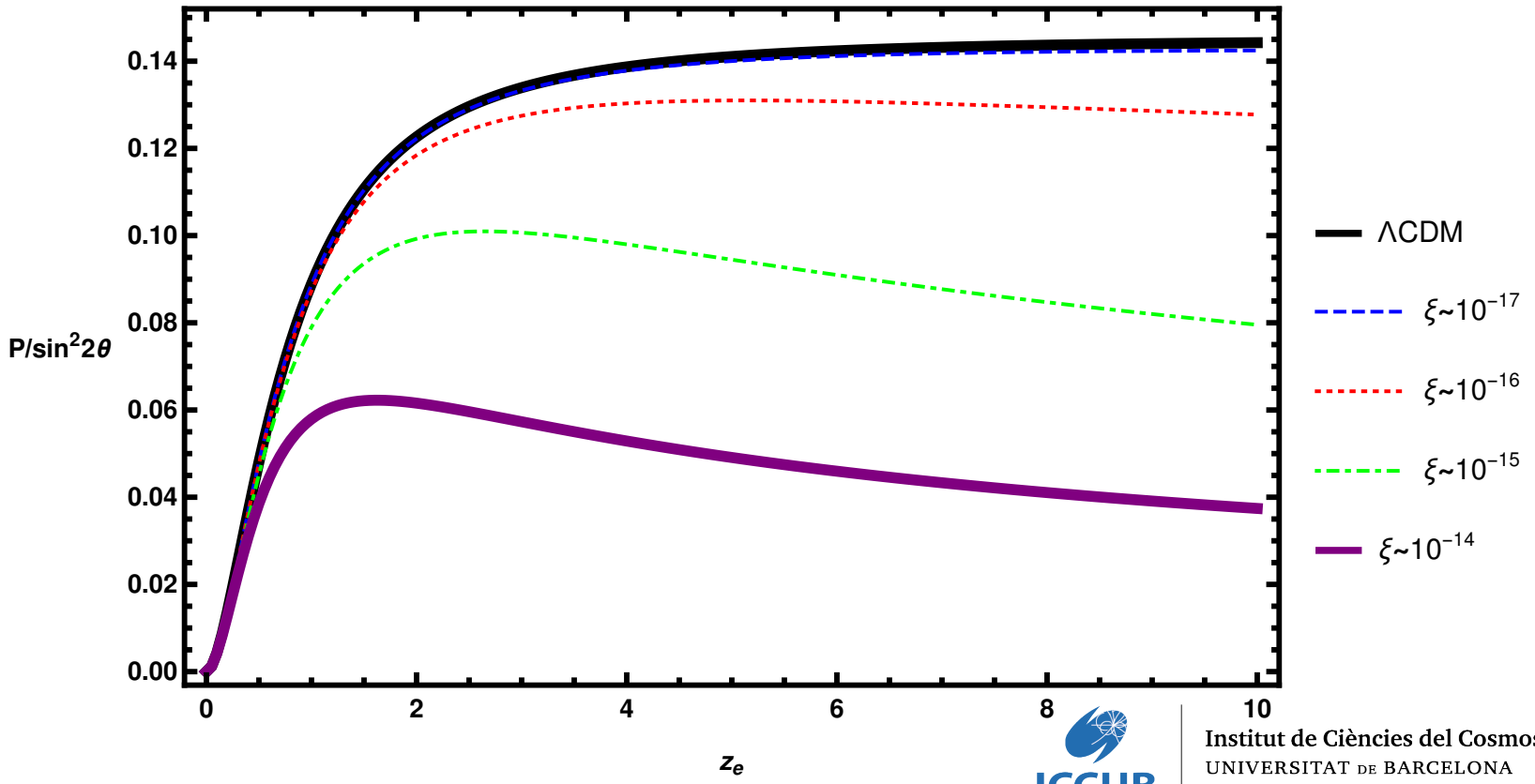
- H_0 ≡Hubble constant today;
- z_{em} ≡emission redshift;
- $\Omega_{m_0}(\Omega_{\Lambda_0})$ ≡matter(DE) density parameter.

Neutrino Oscillation Probability



Neutrino Oscillation Probability

- In flat FLRW with scalar field DE(e.g. quintessence, modified gravity) coupled to neutrinos via $\mathcal{L}_{\text{int}} = \xi \bar{\psi} \gamma^{\mu} \psi \partial_{\mu} \varphi$



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The End

Would you like to know more? You could read the papers or drop me a message on slack or by email. I would be very happy to start a new collaboration!

For more information on spinors in curved spacetime, check: chapter 3.8 of Quantum Fields in Curved Space by N.D.Birell and P.C.W.Davies, or chapter 5 of Quantum Information in Gravitational Fields by M.Lanzagorta.