Damping signatures in future neutrino oscillation experiments

Based on JHEP 06(2005)049

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Outline

- Motivation and general introduction

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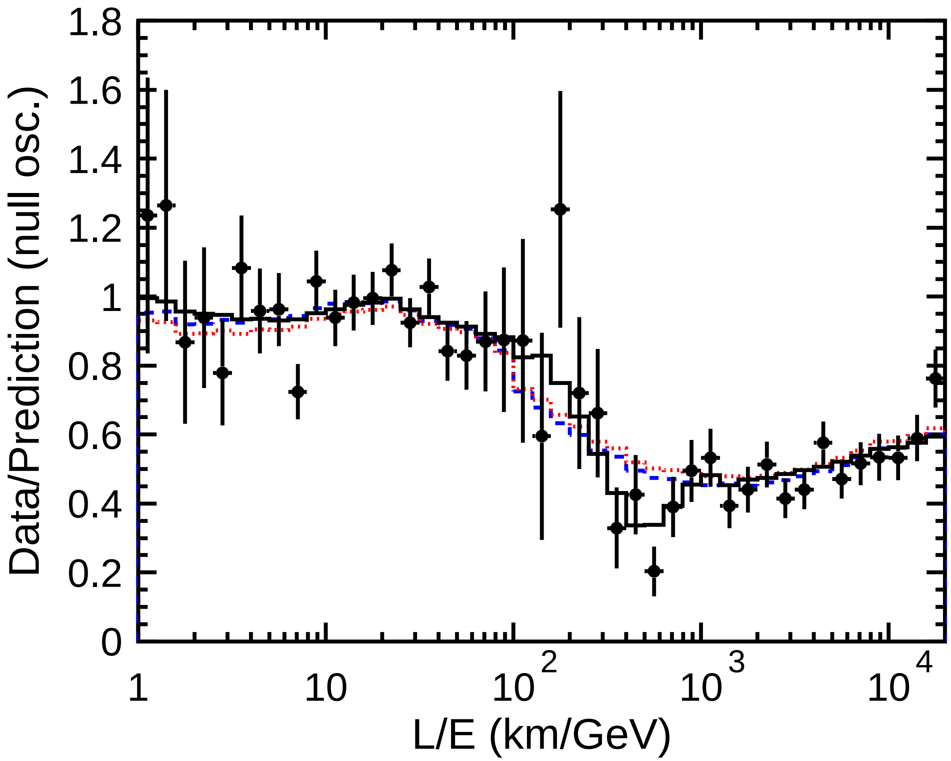
- Fits to experimental data favors neutrino oscillations, i.e., . . .

Oscillation vs. other effects (2)

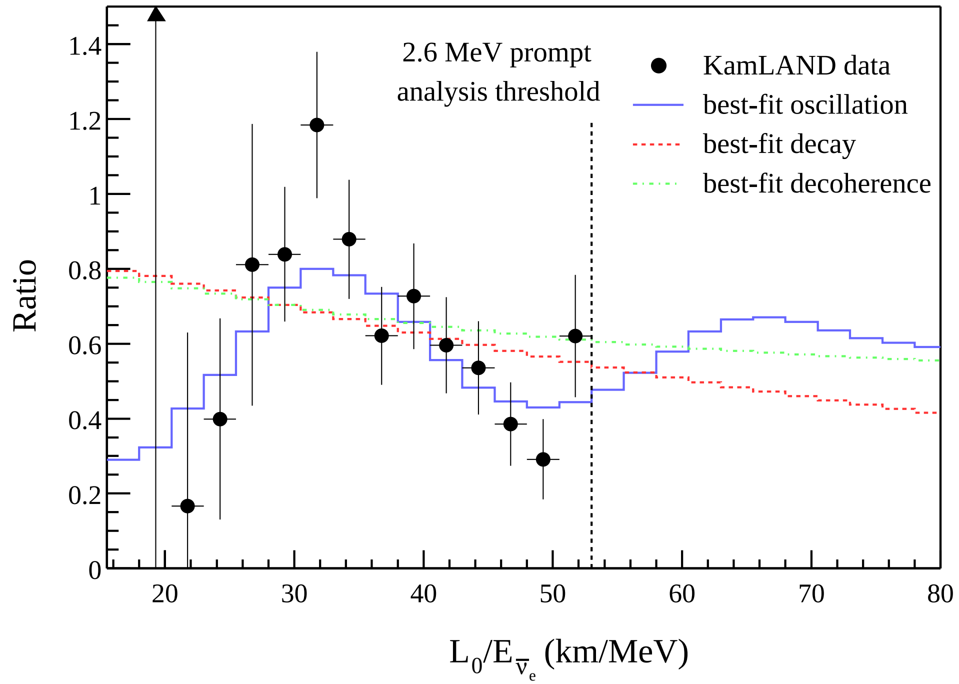
. . . Super-Kamiokande data . . .



Super-Kamiokande collaboration, Phys. Rev. Lett. **93**, 101801 (2004), `hep-ex/0404034`

Oscillation vs. other effects (3)

. . . and KamLAND data.



KamLAND collaboration, Phys. Rev. Lett. **94**, 081801 (2005), `hep-ex/0406035`

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- Attempt to describe a number of effects in a unified framework
- Probability level damping factor approach
- Caveat: Many, but not **all** effects can be described in this framework

Formalism

- The standard neutrino oscillation formula

$$P_{\alpha\beta} = \sum_i \sum_j J_{\alpha\beta}^{ij} \exp\left(-\mathrm{i}\frac{\Delta m_{ij}^2}{2p} L\right)$$

Formalism

- The damped neutrino oscillation formula

$$P_{\alpha\beta} = \sum_i \sum_j D_{ij} J_{\alpha\beta}^{ij} \exp\left(-\mathrm{i}\frac{\Delta m_{ij}^2}{2p} L\right)$$

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- The parameters α_{ij}, β, ξ and γ are dependent on the particular effect
- In many cases, the effective number of free parameters is reduced to one or two

Different effects

- Examples of different effects are:

Damping type	β	γ	ξ
Wave packet decoherence	2	4	2
Decay	1	1	0
Oscillations to ν_s	2	2	0
Absorption	1	-1	0
Quantum decoherence I	1	-2	0
Quantum decoherence II	1 or 2	2	2

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Damped formulas (2f)

- Standard oscillation:

$$P_{\alpha\beta} = \delta_{\alpha\beta} + (1 - 2\delta_{\alpha\beta}) \sin^2(2\theta) \sin^2(\Delta)$$

$$[\Delta = \Delta m^2/(4E)]$$

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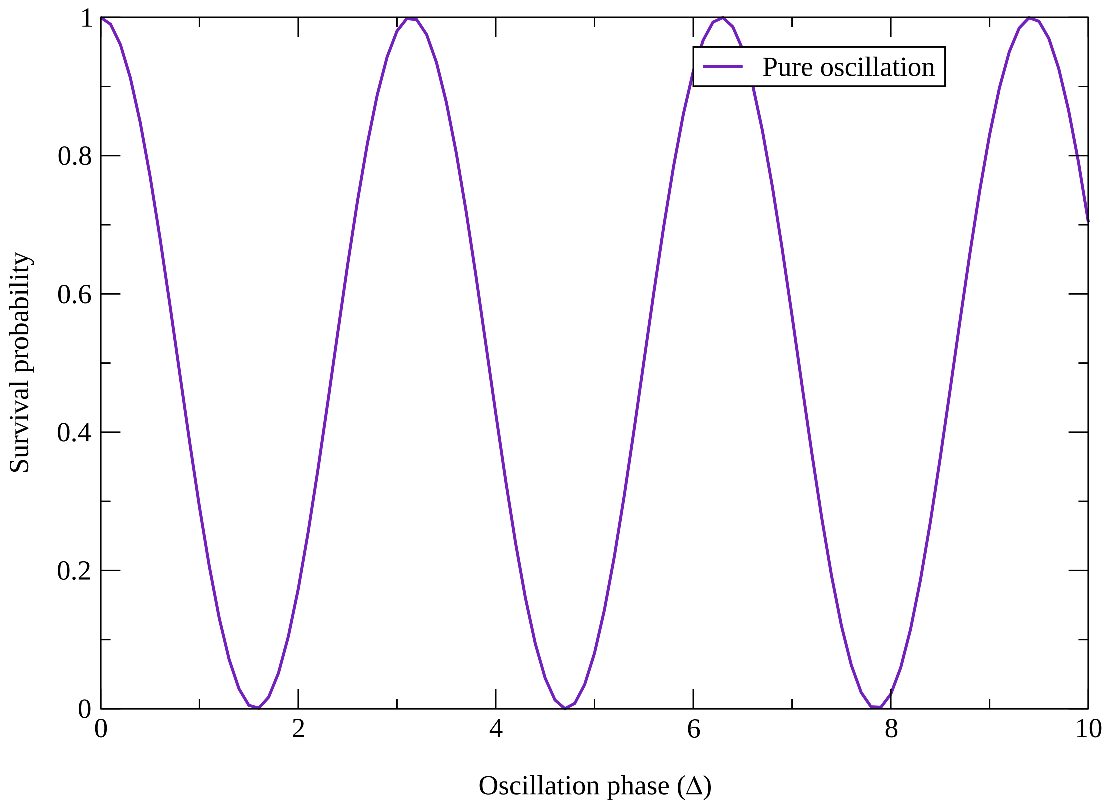
- Decay-like damping (only one decaying mass eigenstate):

$$\begin{aligned} P_{\alpha\alpha} &= \left[(c^2 + As^2)^2 - A\sin^2(2\theta)\sin^2(\Delta)\right], \\ P_{\beta\beta} &= \left[(Ac^2 + s^2)^2 - A\sin^2(2\theta)\sin^2(\Delta)\right], \\ P_{\alpha\beta} &= \frac{1}{4}\sin^2(2\theta)[1 + A^2 - 2A\cos(2\Delta)], \end{aligned}$$

Damped probabilities (2f)

The effect of damping on the neutrino survival probability $P_{\alpha\alpha}$:



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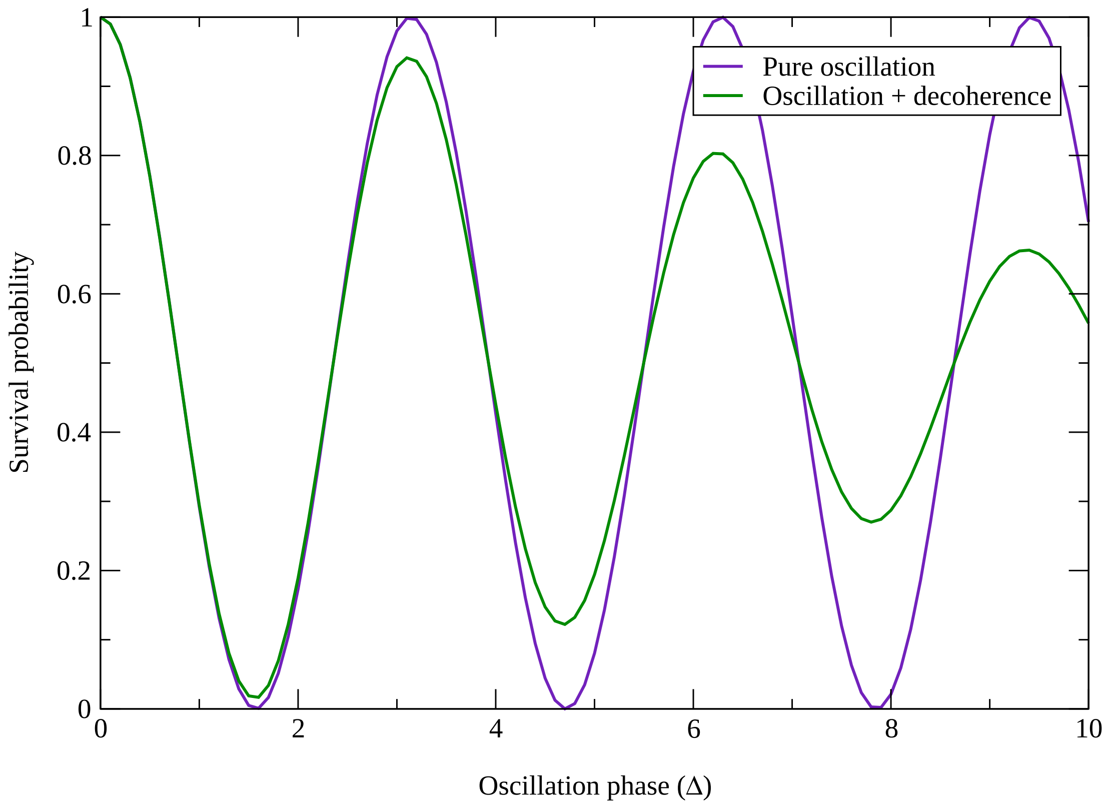

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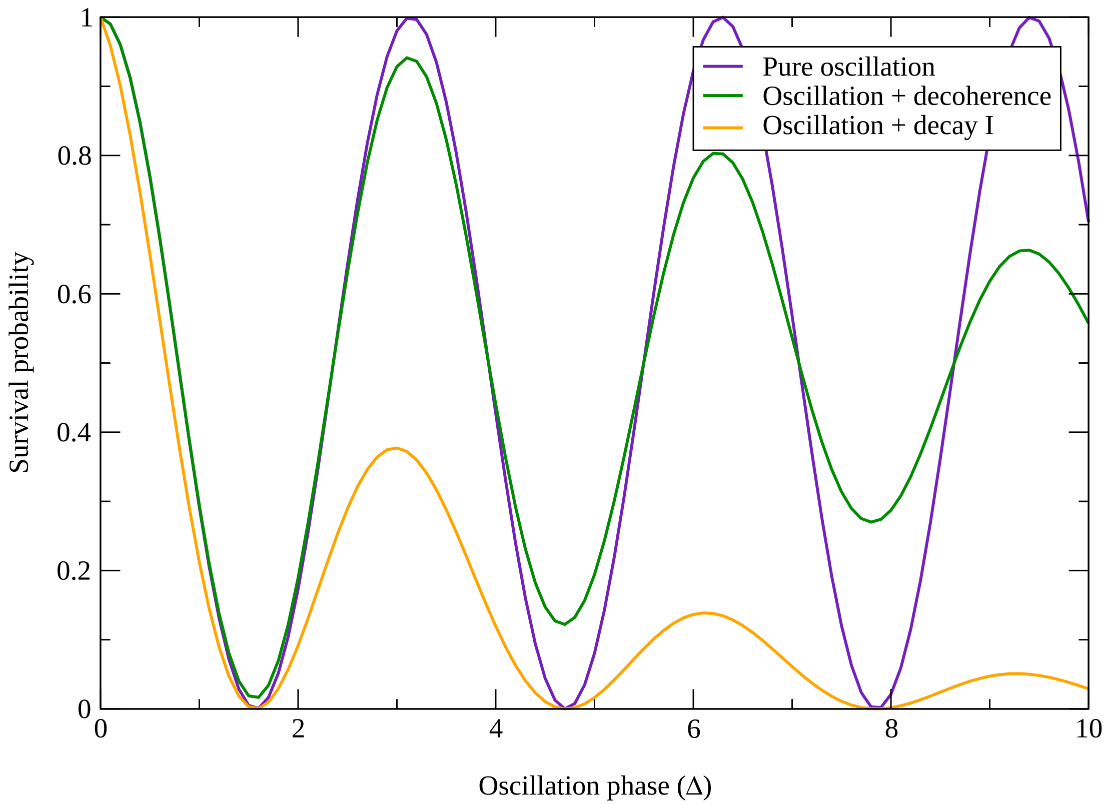

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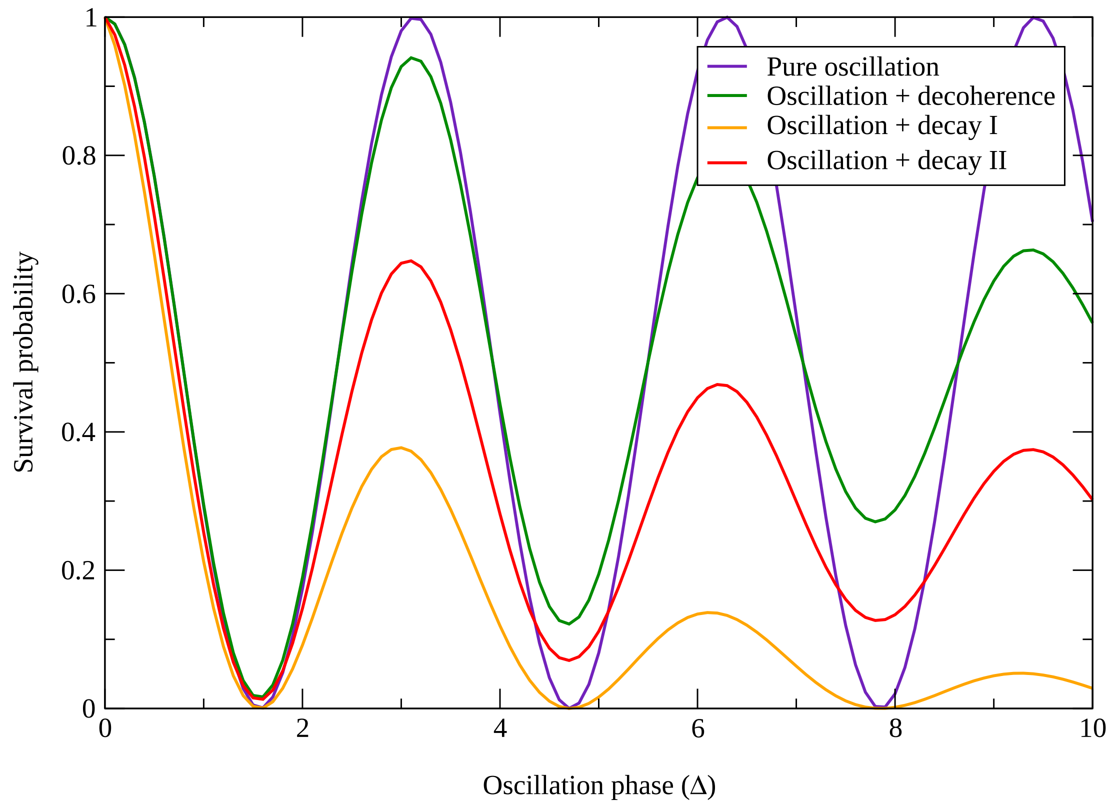

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- Series expansions in s_{13}
- Approximations valid at different types of experiments
- Example, for decoherence-like damping at a beam experiment, approximating $\Delta_{21} \simeq 0$:

$$P_{e\mu} = 2s_{23}^2[1 - D\cos(2\Delta)]\, s_{13}^2 + \mathcal{O}(s_{13}^3)$$

$$P_{\mu\mu} = 1 - \frac{1}{2}\sin^2(2\theta_{23})[1 - D\cos(2\Delta)] + \mathcal{O}(s_{13}^2)$$

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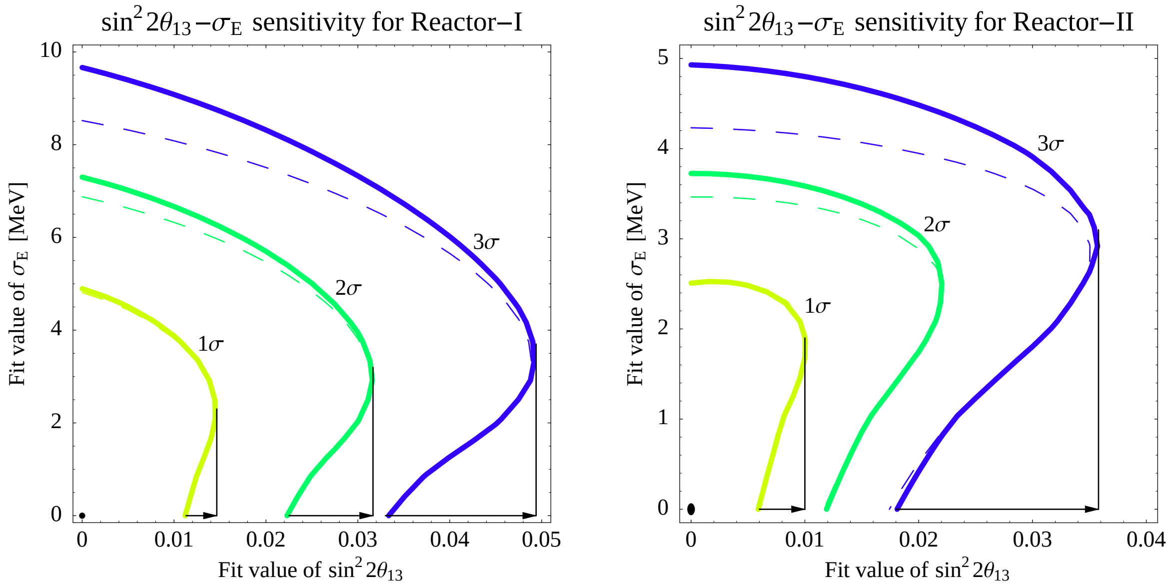
- One additional parameter – necessary to fit to entire parameter space

Larger θ_{13}? (2)

- The result of including the decoherence parameter:



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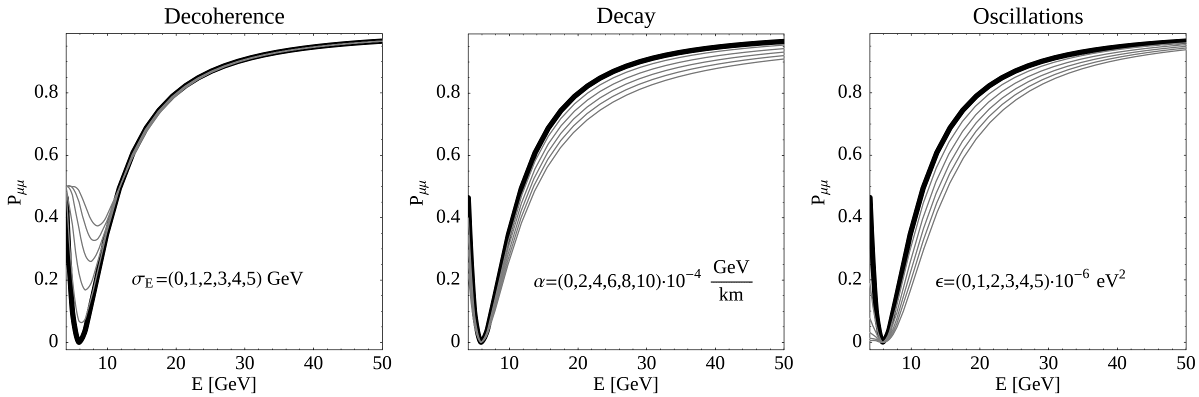

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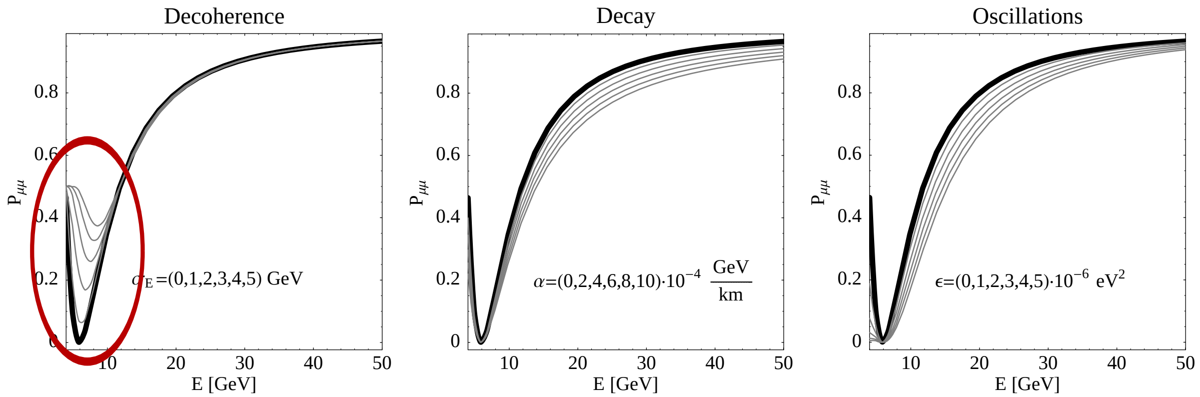

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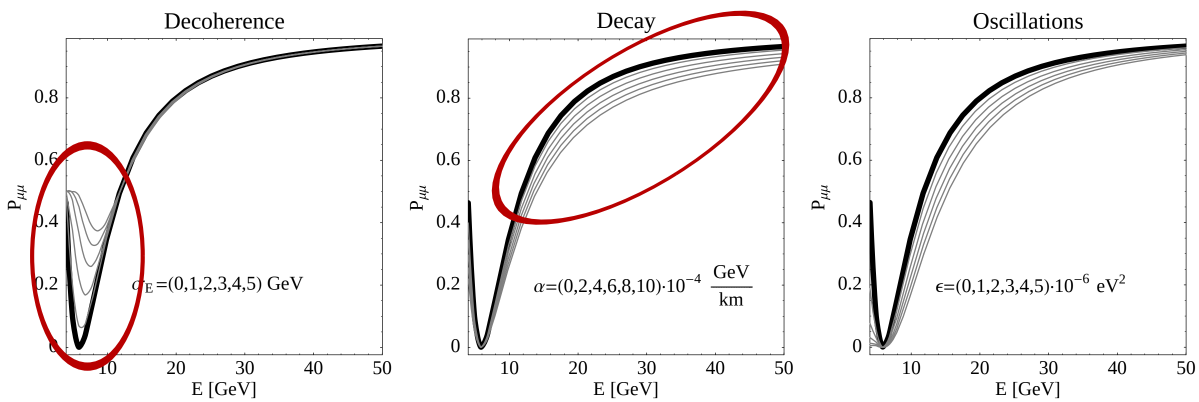

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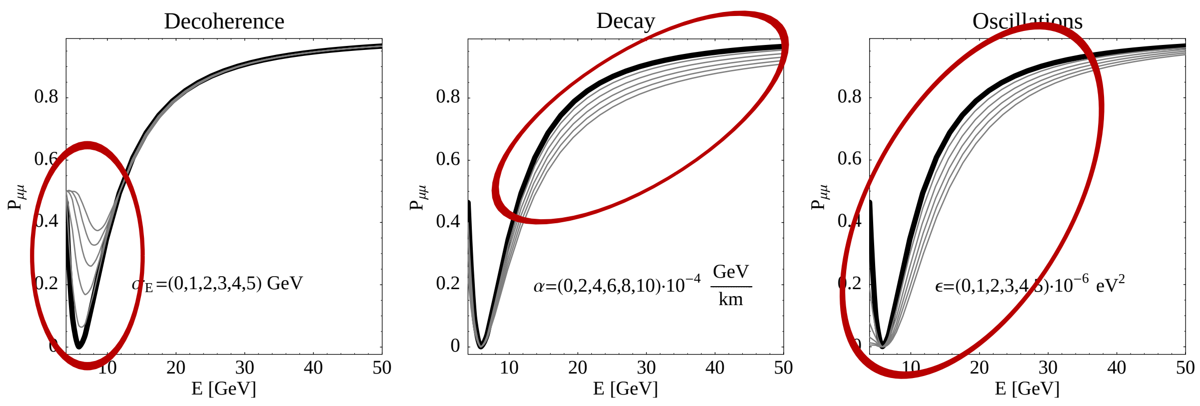

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- How different damping effects may be distinguished