Treatment of n' Production in Heavy Water by STEREO

November 8, 2022 ORNL $n - n'$ Collaboration Meeting

Cary Rock

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Lindblad Equation

$$\frac{d\rho}{dt} = -i\left[H\hat{\rho}\right] + L\rho L^{\dagger} - \frac{1}{2}\left\{L^{\dagger}L, \hat{\rho}\right\}$$

The Lindblad equation has three terms:

- the commutation of ρ and H
- two terms involving the Lindblad operator, L, which describes the interaction of the system with the environment (e.g., absorption)
- The Lindblad operator is problem-dependent

In the STEREO collaboration's calculations, this produces the "swapping probability":

$$p = \frac{2\varepsilon^2}{(\Delta E + V_F)^2 + 4\varepsilon^2 + \frac{(\hbar\Gamma)^2}{4}}$$

STEREO's Swapping Probability

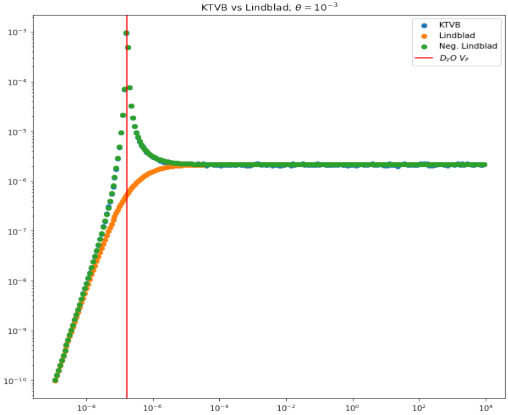
$$p = \frac{2\varepsilon^2}{(\Delta E + V_F)^2 + 4\varepsilon^2 + \frac{(\hbar\Gamma)^2}{4}} = \frac{2\,(\theta\Delta m)^2}{((E_n - E_{n'}) + V_F)^2 + 4\,(\theta\Delta m)^2 + \frac{(\hbar\Gamma)^2}{4}}$$

- The $(\hbar\Gamma)^2$ term is the absorptive term
- Note: their formulation has $\Delta m > 0$, instead of our $\Delta m < 0$, meaning no compensation by V_F.
- They explain this as the SM brane being at a lower energy than the SM' brane (in String theory).

So?

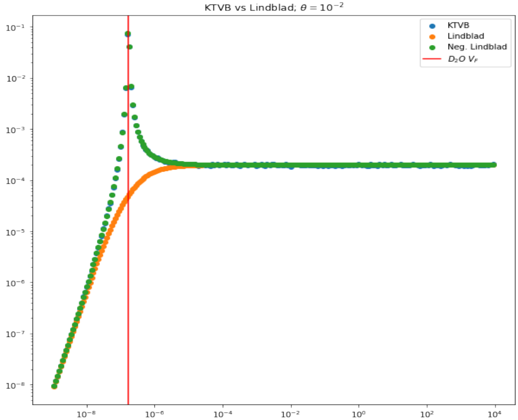
- We expect resonance when $\Delta M = V_F$, they should expect resonance when $-\Delta M = V_F$
- At large positive or negative Δm, the results coincide (ε dominates $\implies p \to \approx \frac{2}{\frac{1}{\theta^2}+4}$).
- In D_2O, absorption is a small contribution, so should see resonances in STEREO's swapping probability in the same place as KTVB's.

Plots - D_2O, $\theta = 10^{-3}$



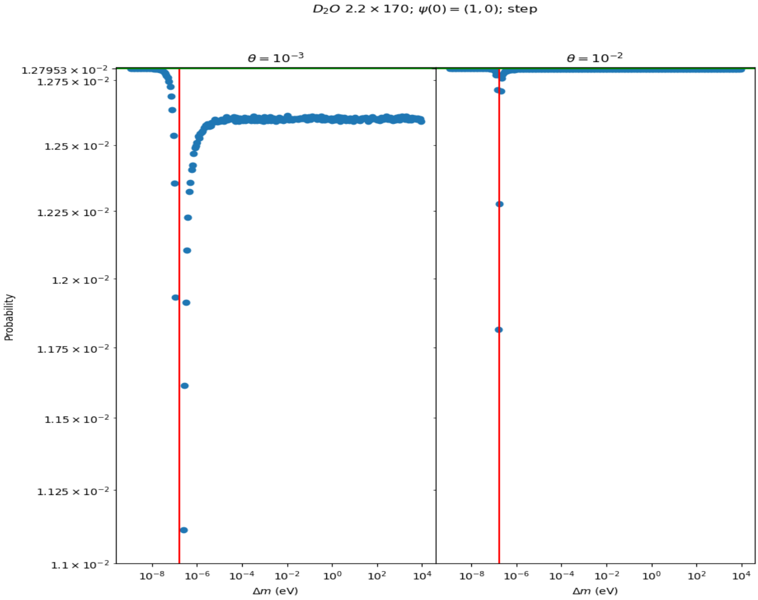
- As expected, plotting STEREO's probability computed with negative mass sees the resonance at the same place (the green). It overlaps with the KTVB result (the blue).
- The same without the negative value of mass sees no resonance (the orange).

Plots - D_2O, $\theta = 10^{-2}$

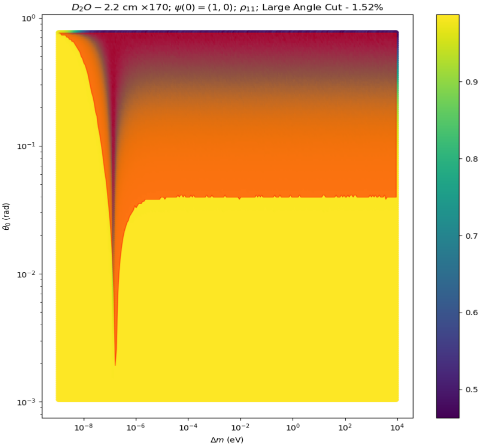


- Qualitatively the same result here.
- For large ΔM, $p \to \frac{2}{10^4+4} \approx 2 \times 10^{-4}$

Plots - KTVB Absorption for $\theta = 10^{-3}$ and $\theta = 10^{-2}$



Excluded Region Plot - $\psi(0) = (1, 0)^T$



- Everything in the red-shaded region should be excluded. The effects of large-angle oscillations would be easily noticed.

END