DTP Interaction Meeting 2018

8 February, 2018

Fast Neutrino Flavor Flips
and
Dark Matter with Excited States

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Fast Neutrino Flavor Flips

$$i\partial_t|\nu_i\rangle = \left(\sum_{j=1}^{N}(1-\hat{p}_j\cdot\hat{p}_i)|\nu_j\rangle\langle\nu_j| + \ldots\right)|\nu_i\rangle$$

If the neutrino evolves at a frequency proportional to N, it is called "fast".

Conditions for such fast oscillations to take place? Angular spectral crossing.

BD and Manibrata Sen (2018, PRD)

Why? Pinching of roots of the dispersion relation.

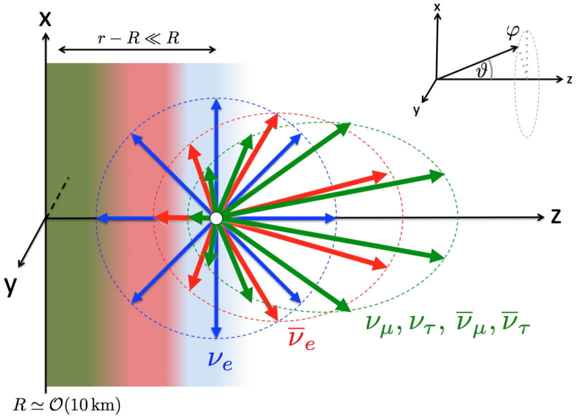
Bari Group and BD (2017, PRD)

Can this happen in a realistic supernova environment? Yes!

BD, Alessandro Mirizzi, Manibrata Sen (2017, JCAP)

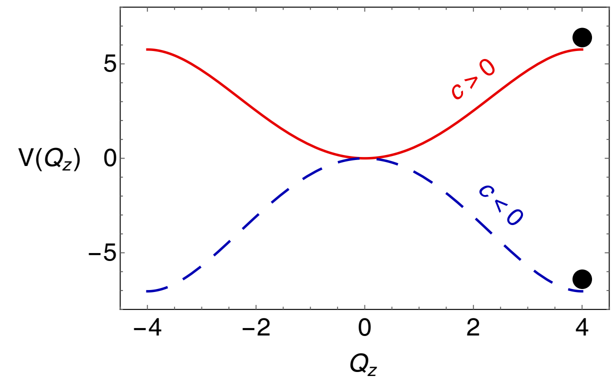
Fast Neutrino Flavor Flips

1



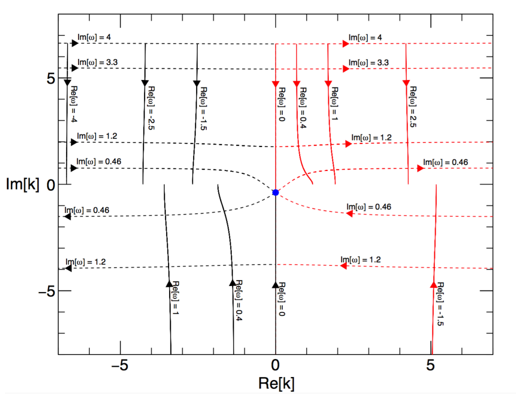
Difference of the angular spectra must pass through zero.

2



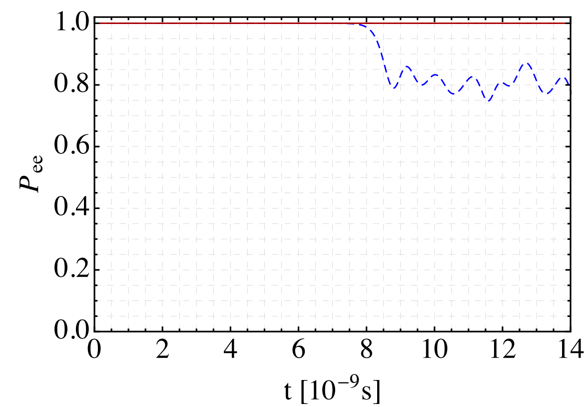
For a simple model, can analytically solve the problem.
Angular spectrum = Sign of the potential energy term.

3



Equivalent to pinching of roots of the dispersion relation. Dominates the large-time behavior.

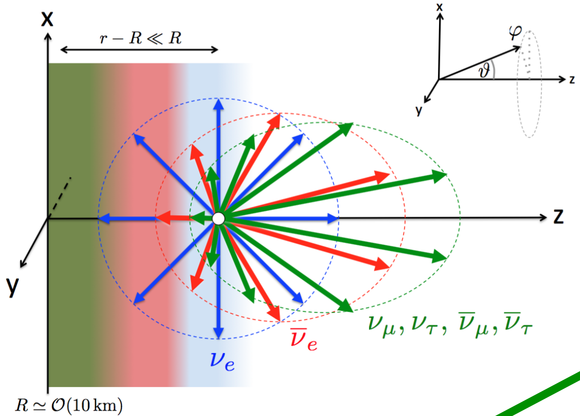
4



Flavor can convert over nanoseconds, for realistic supernova neutrino fluxes. Has implications for explosion.

Fast Neutrino Flavor Flips

1



Difference of the angular spectra mu

2

alytically solve the problem.
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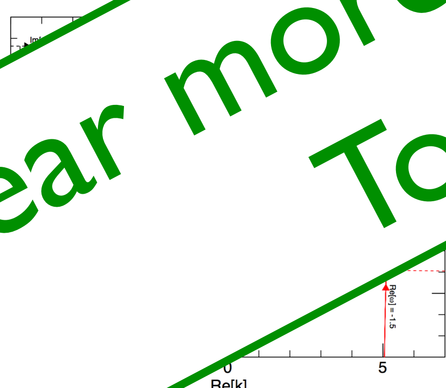
Hear more from Manibrata Sen
Today Afternoon

3



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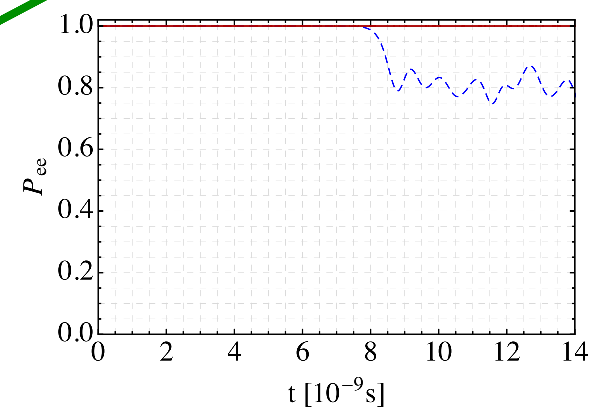


Flavor can convert over nanoseconds, for realistic supernova neutrino fluxes. Has implications for explosion.

DM with Excited States

If DM particles, A, have a heavier partner B, it raises the possibility of "off-diagonal" interactions between A and B, that give qualitatively new effects.

- For annihilation AA ➔ anything, it imposes an angular momentum selection rule on the Sommerfeld correction. This can make the DM annihilation efficient at later times, and non-monotonically dependent on the typical velocity (or mass of the halo).

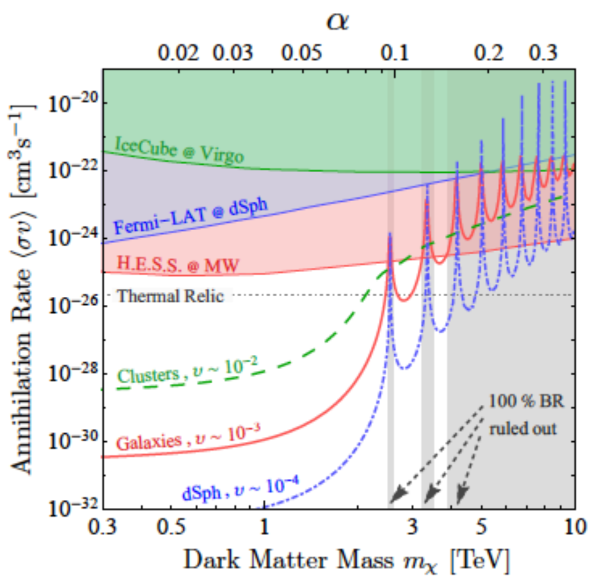
Anirban Das and BD (2017, PRL)

- We showed that in scattering processes, such as AA ➔ AA, the B particles can be produced as intermediates and decay back to A. This produces a new kind of energy loss mechanism in DM halos.

Anirban Das and BD (2018, PRD)

DM with Excited States

1

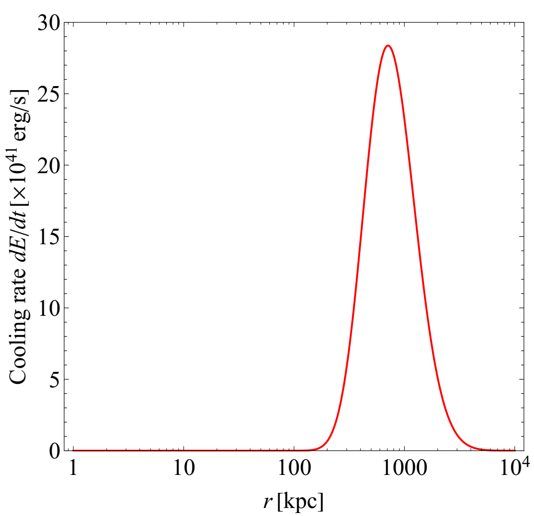


The p-wave cross-section for annihilation can be larger than than s-wave in the v~10^-3 range.

Makes Milky Way a prime candidate for observing DM annihilation.

A new class of models can be built to evade dwarf galaxy and CMB constraints, but predicts promising signals at galaxies and clusters.

2



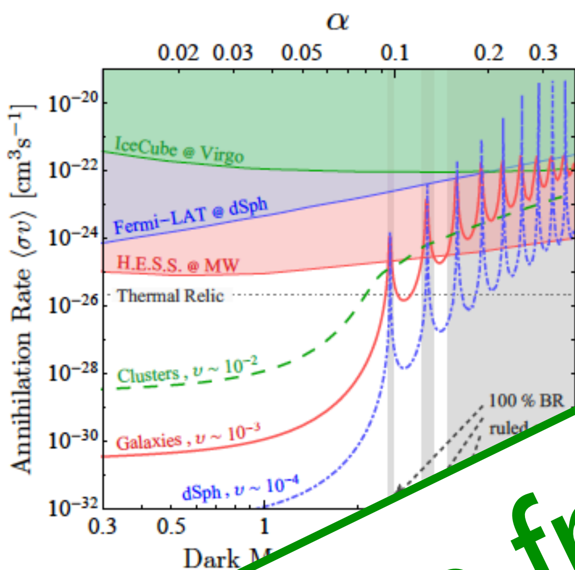
The excitation-followed-by-decay process leads to loss of energy from dark matter halos.

This happens at/close to the virial radius due to competition between density and velocity.

In principle, can be used to distinguish this model from others (even those with multiple states).

DM with Excited States

1



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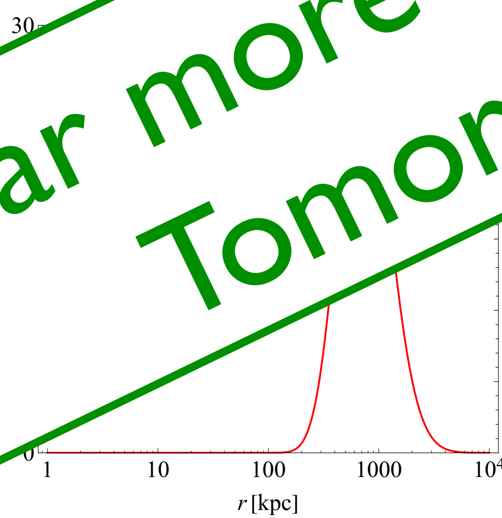

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In principle, can be used to distinguish this model from others (even those with multiple states).

Hear more from Anirban Das Tomorrow Morning

Summary

- Neutrinos can oscillate fast (frequency ~ N) if the angular distributions obey certain conditions.

  Can have impact on SN dynamics.

- Dark Matter with more than one state has very unusual annihilation and scattering if the off-diagonal coupling dominates.

  Can have impact on our existing DM searches.