A New Probe of Relic Neutrino Clustering using Decaying Heavy Dark Matter

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Washington University in St. Louis

Particle Physics on the Plains
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Outline

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- Summary

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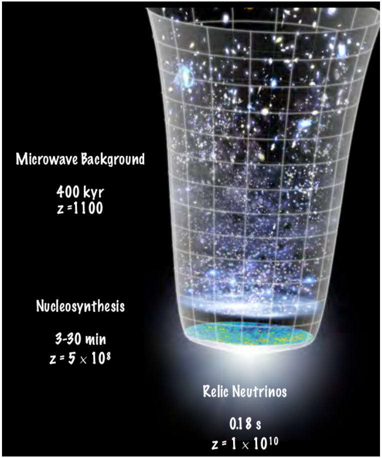

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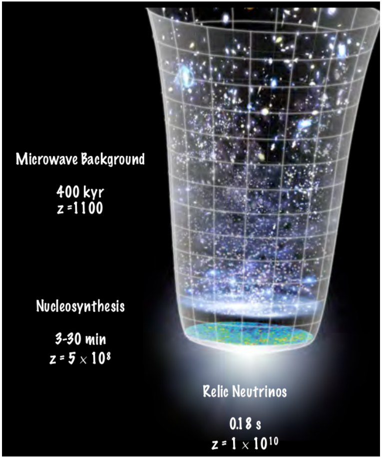

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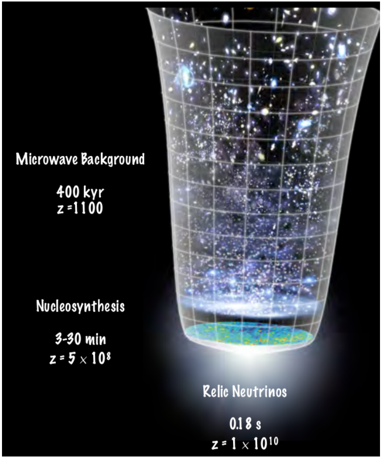

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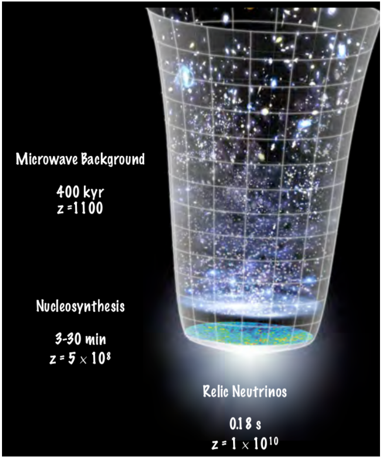

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- Detection of CνB will validate modern cosmological theory.
- It will provide a window to the first second of creation of the universe.

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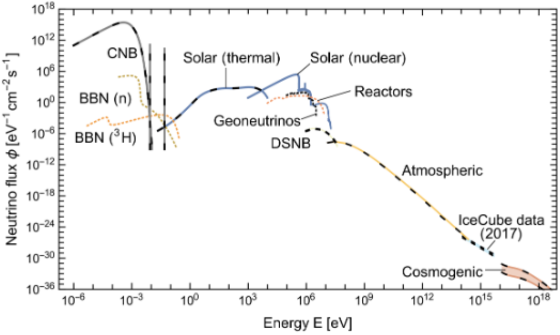

Figure: [1910.11878]

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- The current strongest experimental constraint on the local neutrino overdensity from the **KATRIN** experiment is $\xi < 1.1 \times 10^{11}$ (95% CL).

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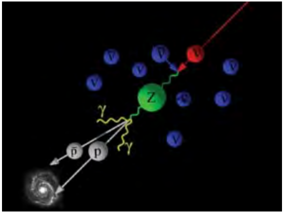

Figure: [T. Weiler (PRL '82)]

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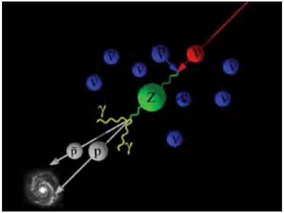

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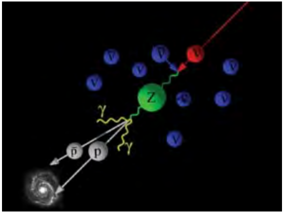

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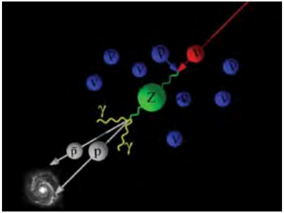

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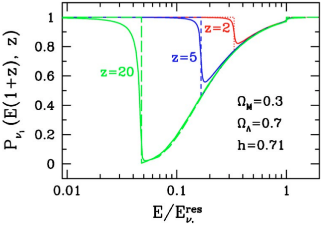

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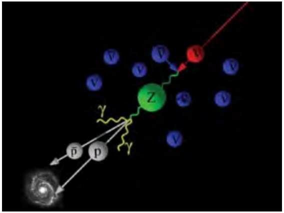

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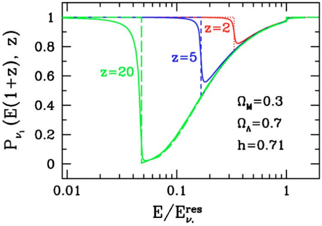

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Difficulty:- Dependent on redshift and source energy distribution of the unknown cosmic ray sources.

Using other SM meson resonances

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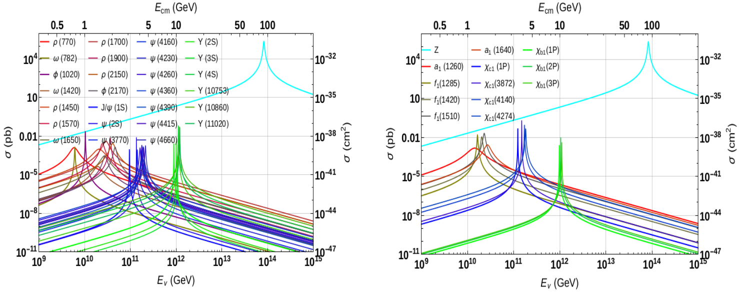

Figure: [BD, Soni (2112.01424)]

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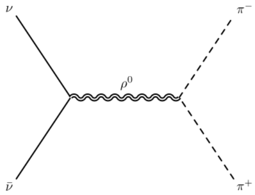

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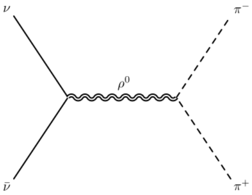

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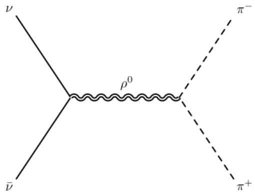

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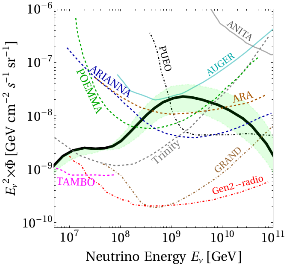

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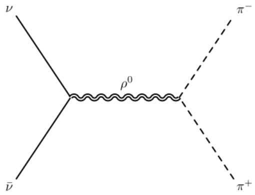

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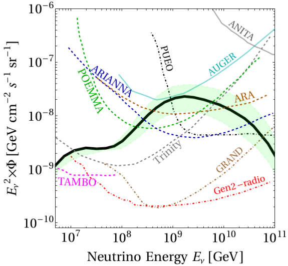

The cosmogenic neutrino flux typically peaks around $10^{18}eV$

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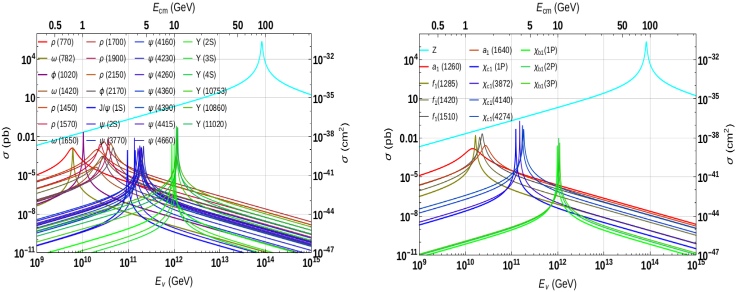

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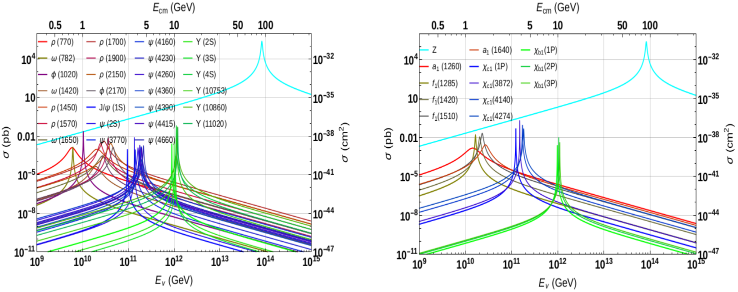

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- For the rest meson resonances, either resonance energy is beyond $10^{18} eV$ or the resonances have narrow width.

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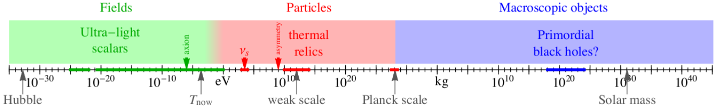

Figure: [2110.02821]

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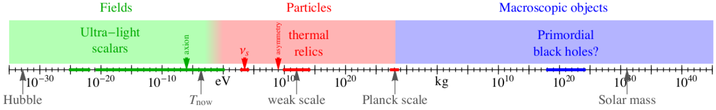

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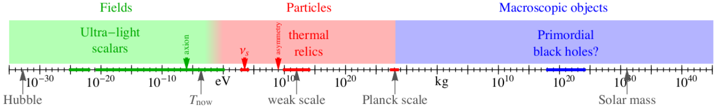

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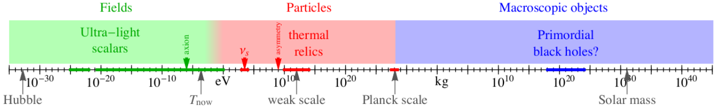

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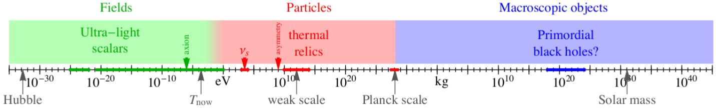

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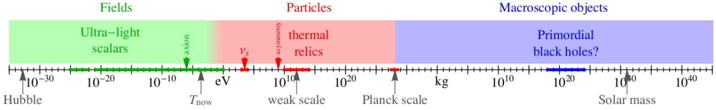

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Focus is on decaying dark matter

Neutrino flux from decaying DM

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where,

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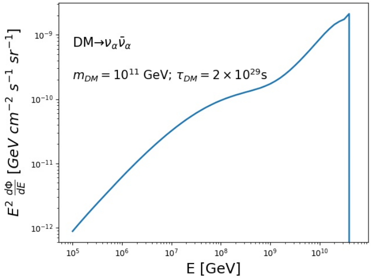

HDMSpectra

Result

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$$N_{w/wo} = \int_{E_{min}}^{E_{max}} dE \;\; T \;\; \Omega \;\; A_{eff}(E) \;\; \Phi(E, m_{DM}, \tau_{DM}) \;\; R(E, m_1, \xi, z)$$

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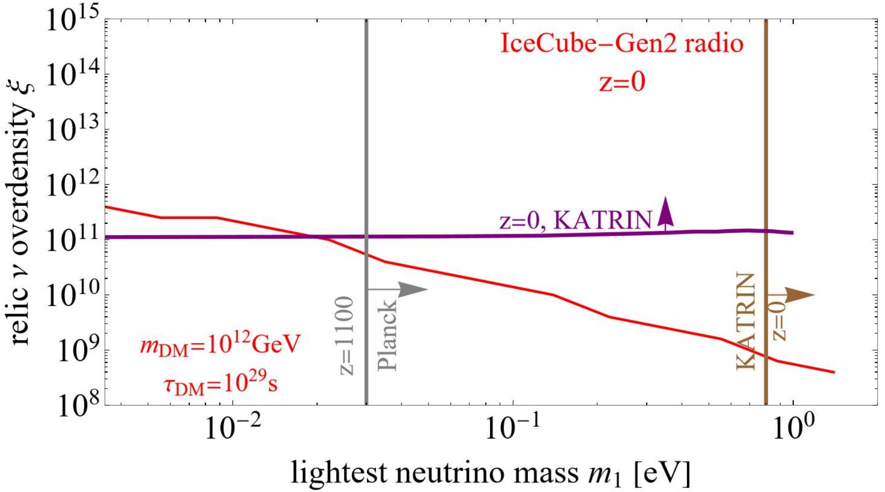

IceCube−Gen2 radio
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z=0, KATRIN
z=1100
Planck
KATRIN
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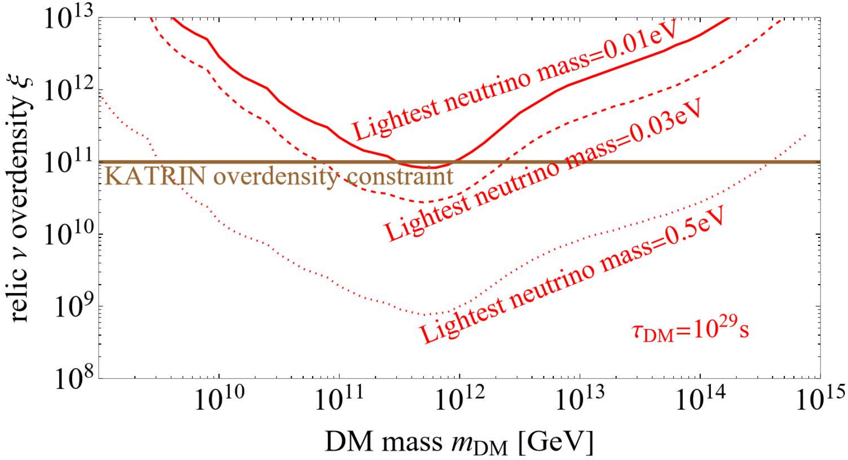
$m_{\rm DM}=10^{12}$GeV
$\tau_{\rm DM}=10^{29}$s
relic ν overdensity ξ
lightest neutrino mass m_1 [eV]
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{-2}
10^{-1}
10^{0}

Result



10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
relic ν overdensity ξ
10^{10}
10^{11}
10^{12}
10^{13}
10^{14}
10^{15}
DM mass $m_{\rm DM}$ [GeV]
KATRIN overdensity constraint
Lightest neutrino mass=0.01eV
Lightest neutrino mass=0.03eV
Lightest neutrino mass=0.5eV
$\tau_{\rm DM}=10^{29}$s

Result

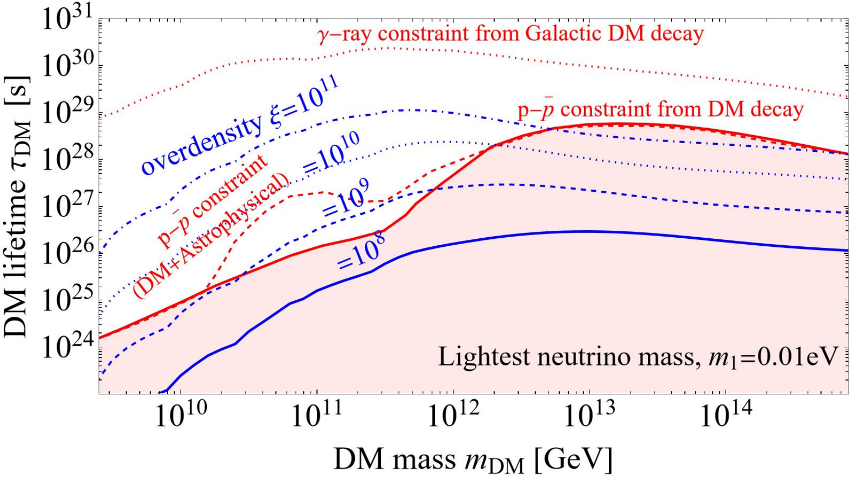


Figure: [Das,Murase, Fujii (PRD ’23)]

Result

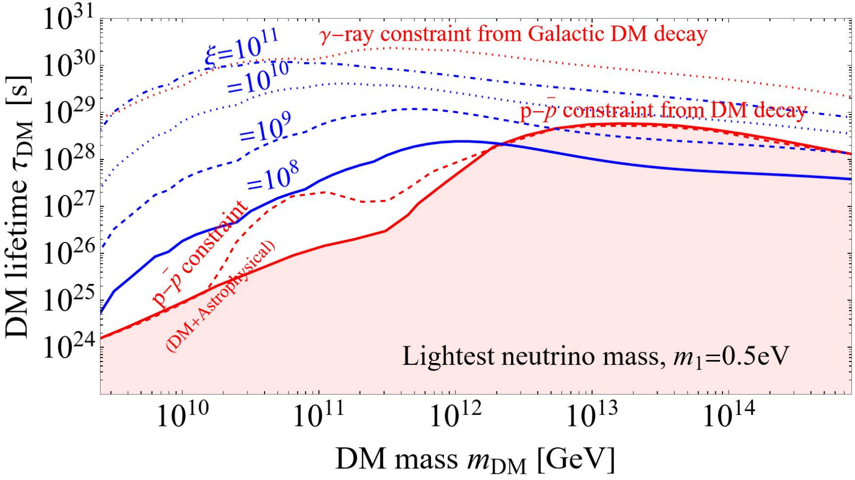


Figure: [Das,Murase, Fujii (PRD '23)]

Summary

- The existence of relic neutrino background is a strong prediction of big bang cosmology.
- Its direct detection is difficult because of its low kinetic energy.
- Its indirect detection via cosmic ray-CνB scattering is limited to inclusion of only ρ meson resonance.
- Heavy dark matter decaying into neutrinos can be resonant scattered by relic neutrinos and this can be a new probe of detecting relic neutrino.

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Thank you :)