Kaluza-Klein Dark Matter Annihilation in the Sun

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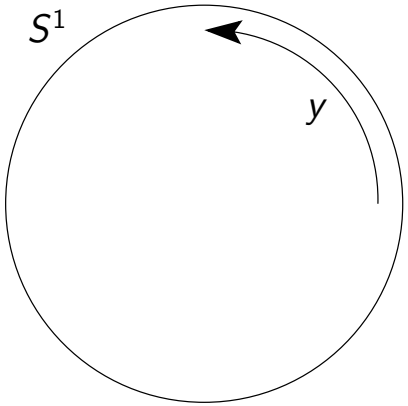
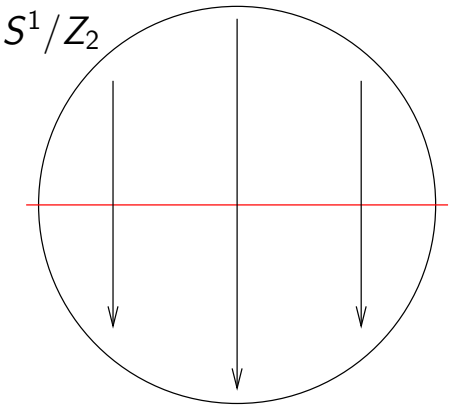
Mainly based on MB, Melbéus, Ohlsson, JCAP 01(2010)018, 0910.1588

1 KK Dark Matter

KK models

- Simplest Kaluza–Klein model: One extra dimension compactified as the circle S^1
  - Quantized extra-dimensional momentum
  - KK masses as $m_n^2 = m_0^2 + p_5^2 = m_0^2 + (n/R)^2$





- Orbifold compactification: $S^1/\mathbb{Z}_2$
  - Non-conservation of extra-dimensional momentum - remaining $\mathbb{Z}_2$ KK parity
  - Fix points at boundaries $\Rightarrow$ boundary localized terms (BLTs)

KKDM candidates

We consider Universal Extra Dimensions (UED) – KK towers of all particles

- Electromagnetically neutral first KK modes can be DM candidates
- With one extra dimension:
  - Neutrinos $\nu^{(1)}$
  - Gauge bosons $B^{(1)}$, $W_3^{(1)}$
  - Neutral Higgses $\phi_0^{(1)}$, $\phi_0^{(1)*}$
  - Gravitons $g^{(1)}$
- With two extra dimensions, also:
  - Adjoint scalars $B_H^{(1)}$, $W_{3H}^{(1)}$

WIMP capture and annihilation

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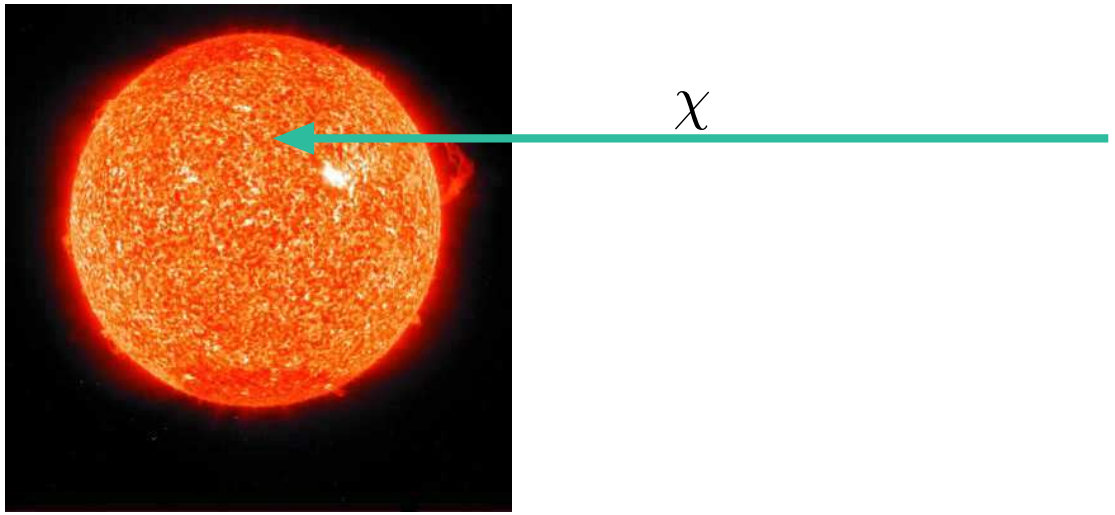

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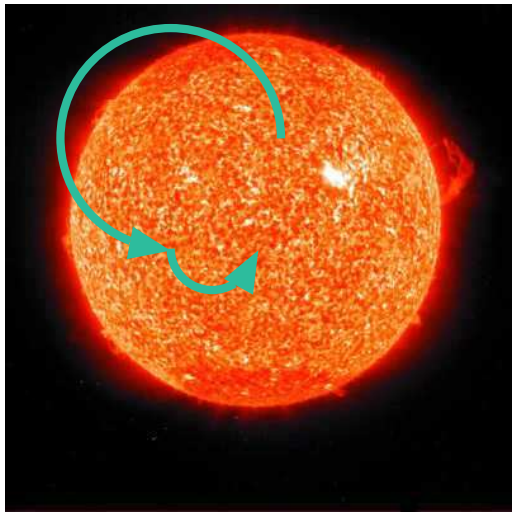

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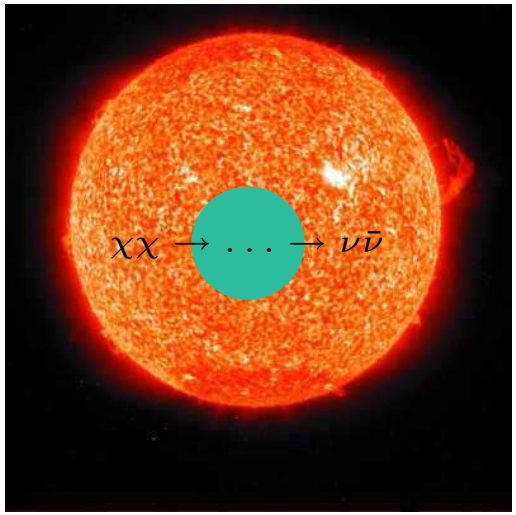

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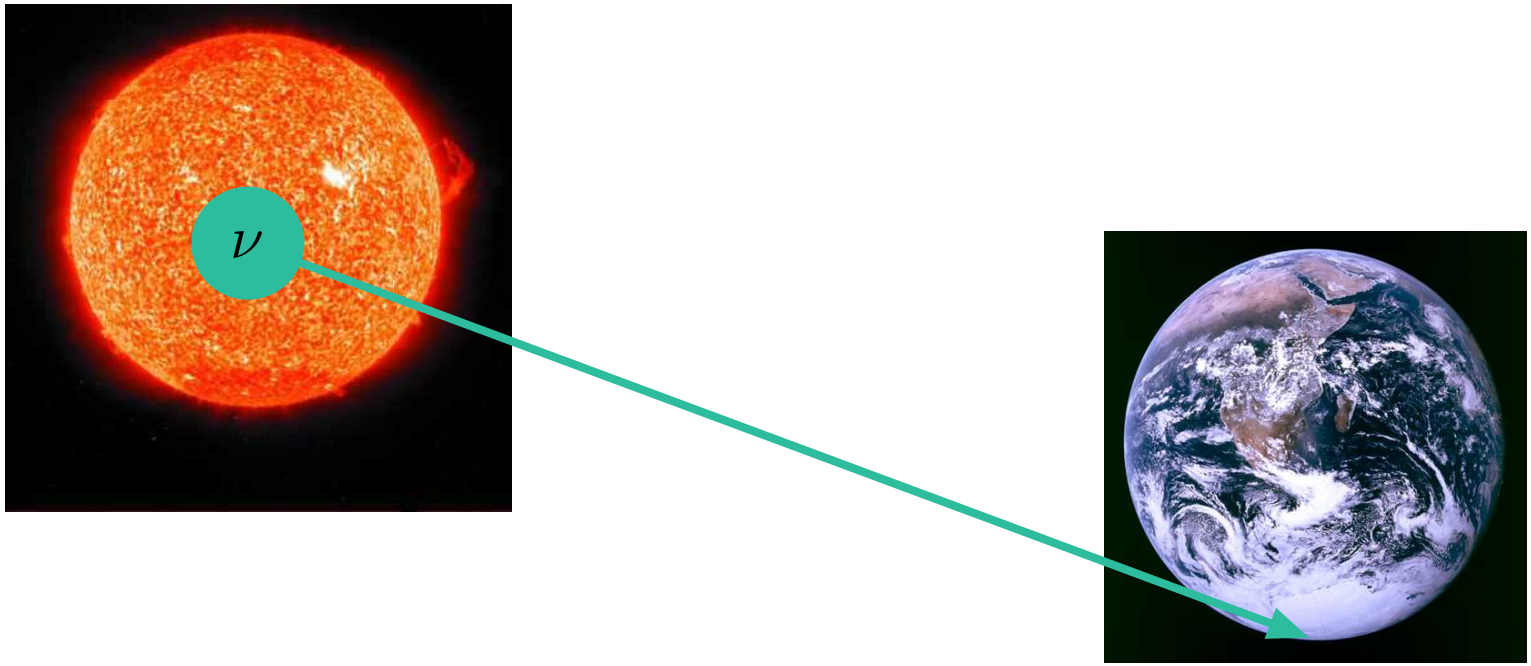
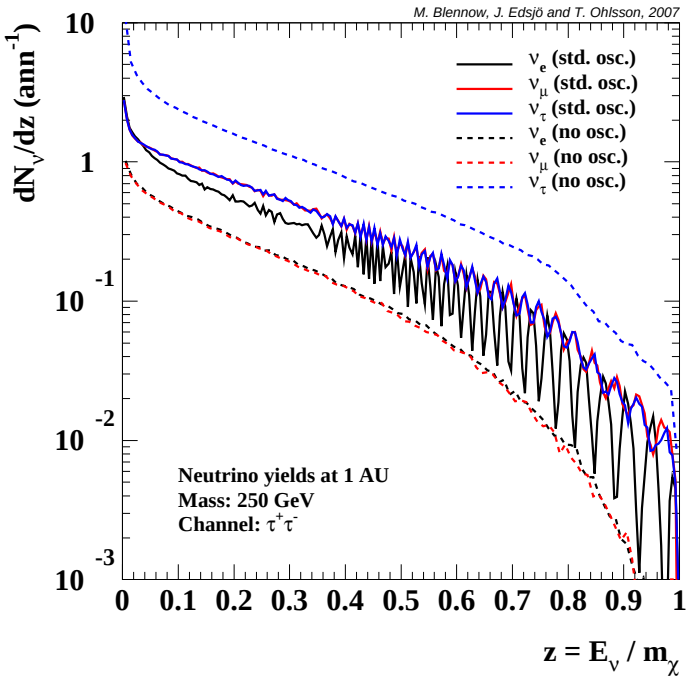


Interactions and oscillations

- Neutrinos are subject to interactions with solar medium as well as oscillations
- Treated in a full event based Monte Carlo using the WimpSim software

  MB, Edsjö, Ohlsson, JCAP 01(2008)021
- Fully consistent with density matrix approach



Signal candidates

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- Neutrinos $\nu^{(1)}$ – ruled out by direct detection
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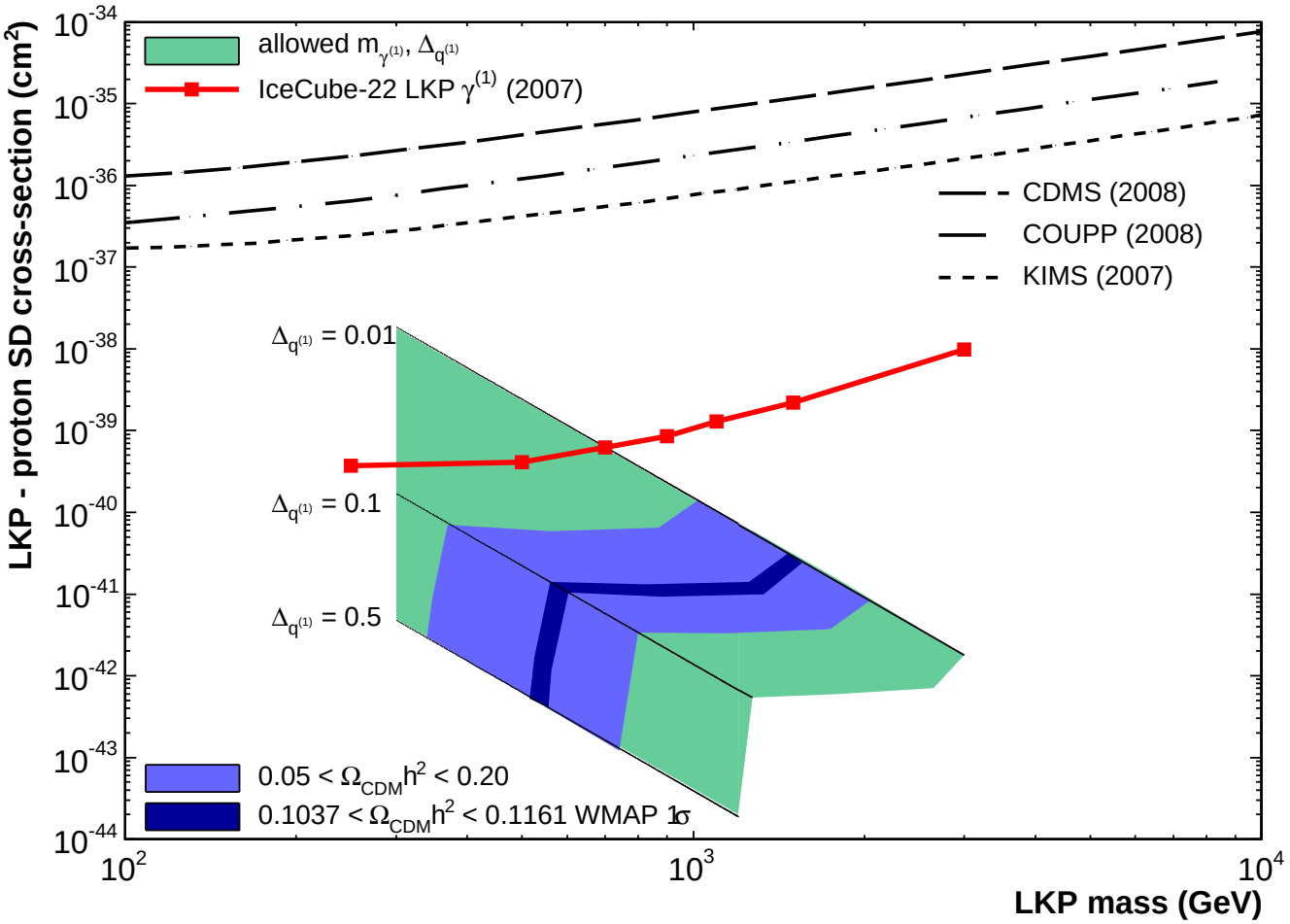
Related works

- Neutrinos from KKDM in the Sun first investigated by Hooper and Kribs [PRD67(2003)055003]
  - Considers the five-dimensional minimal UED model ($B^{(1)}$ LKP)
- Later extended by Flacke, Menon, Hooper, and Freese [0908.0899]
- The IceCube collaboration has also analyzed the minimal model [PRD81(2010)057101]

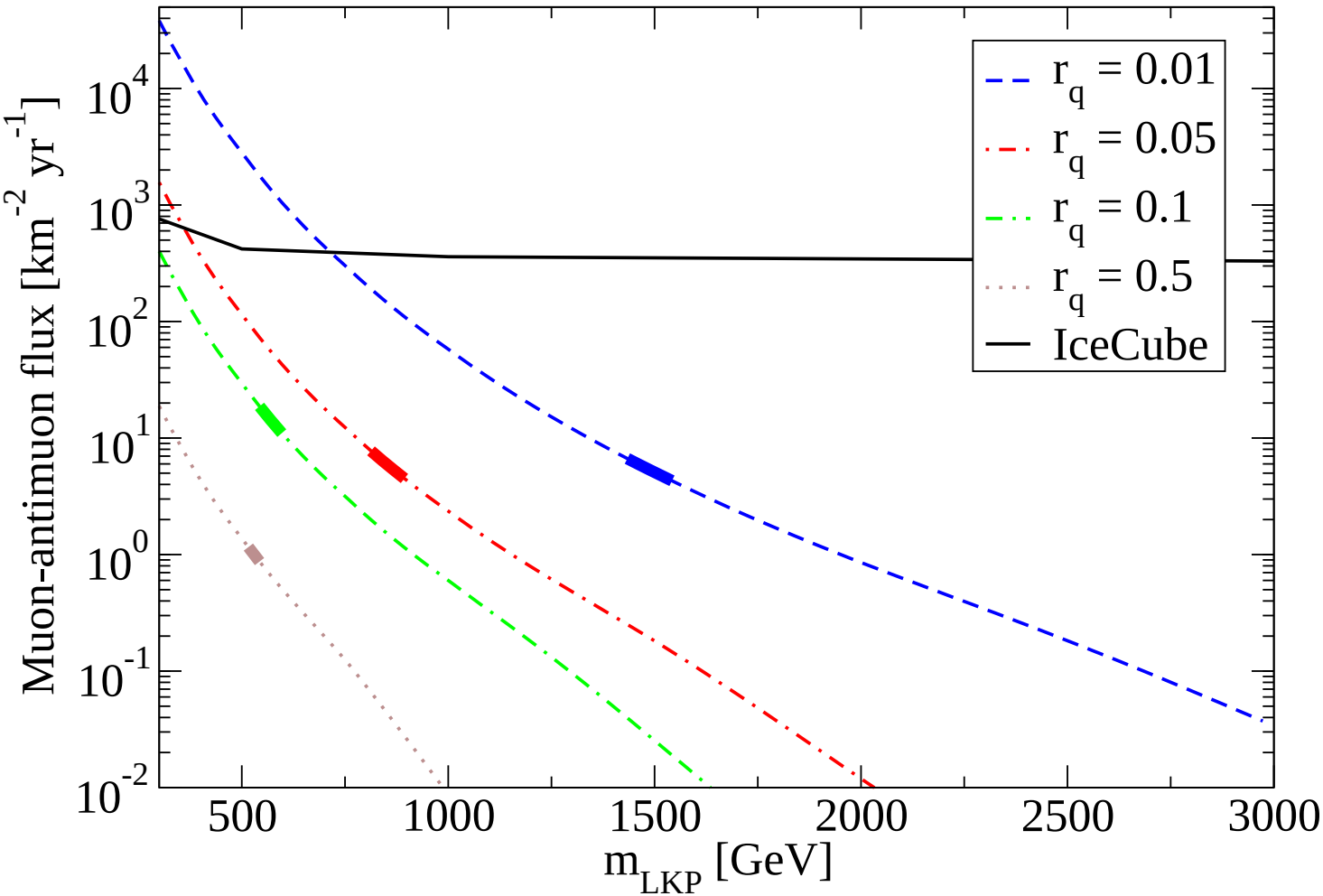
IceCube results [PRD81(2010)057101]



Our work

- KKDM beyond the minimal model
- Indirect neutrino signals from all possible dark matter candidates within the model
- Extension also to a six-dimensional model
- Using WimpSim and DarkSUSY for the capture rate, neutrino fluxes and interactions in the detector
  - More detailed treatment giving different results, but not significantly different
- Assuming different LKPs, not considering the effects on couplings and on the rest of the spectrum

KK hypercharge boson



Neutral KK $SU(2)_L$ boson