宇宙の進化と素粒子模型

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神奈川大：粕谷

佐賀大：高橋智

国内旅費：10万円

Cosmological constraints on dark matter models with velocity-dependent annihilation cross section

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Dark Matter Annihilation/Decay

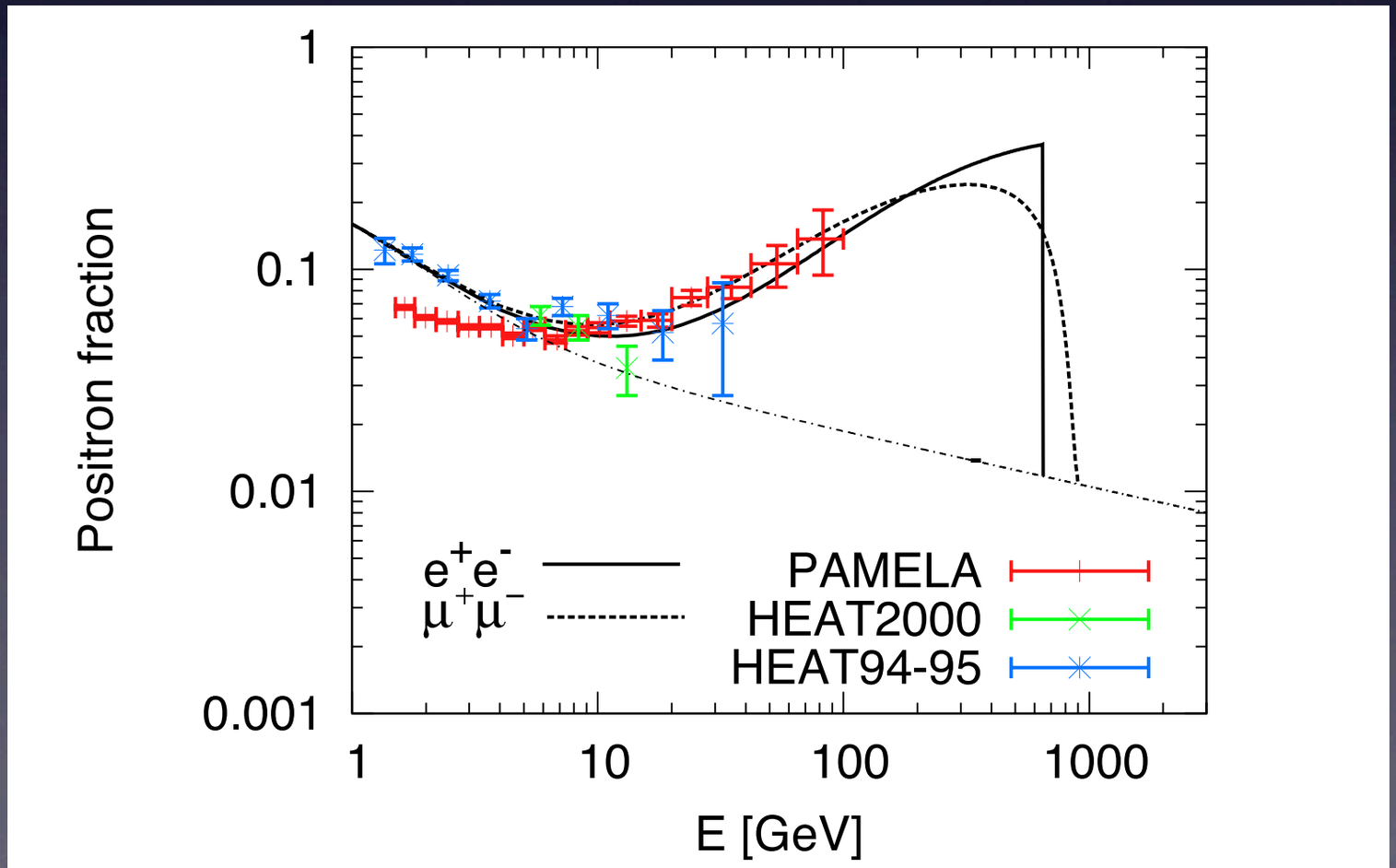
- Electron-positron spectral anomaly observed by PAMERA

  Annihilation of dark matter with mass ~1TeV and cross section

$$\boxed{\langle \sigma v \rangle \sim 10^{-23} \mathrm{cm}^{-3} \mathrm{s}^{-1}}$$

- This is much larger than expected from thermal relic

$$\langle \sigma v \rangle_{\mathrm{TH}} \sim 10^{-26} \mathrm{cm}^{-3} \mathrm{s}^{-1}$$



- Velocity-dependent cross section

$$\langle \sigma v \rangle = \frac{\langle \sigma v \rangle_0}{\epsilon + (v/v_0)^n}$$

freeze-out $\quad T_{\rm fo} \simeq m/25 \quad v_0 \simeq \sqrt{3}/5 \quad \Rightarrow \quad \langle \sigma v \rangle_0$

our galaxy $\quad v = 10^{-3} \quad \Rightarrow \quad \langle \sigma v \rangle \gg \langle \sigma v \rangle_0$

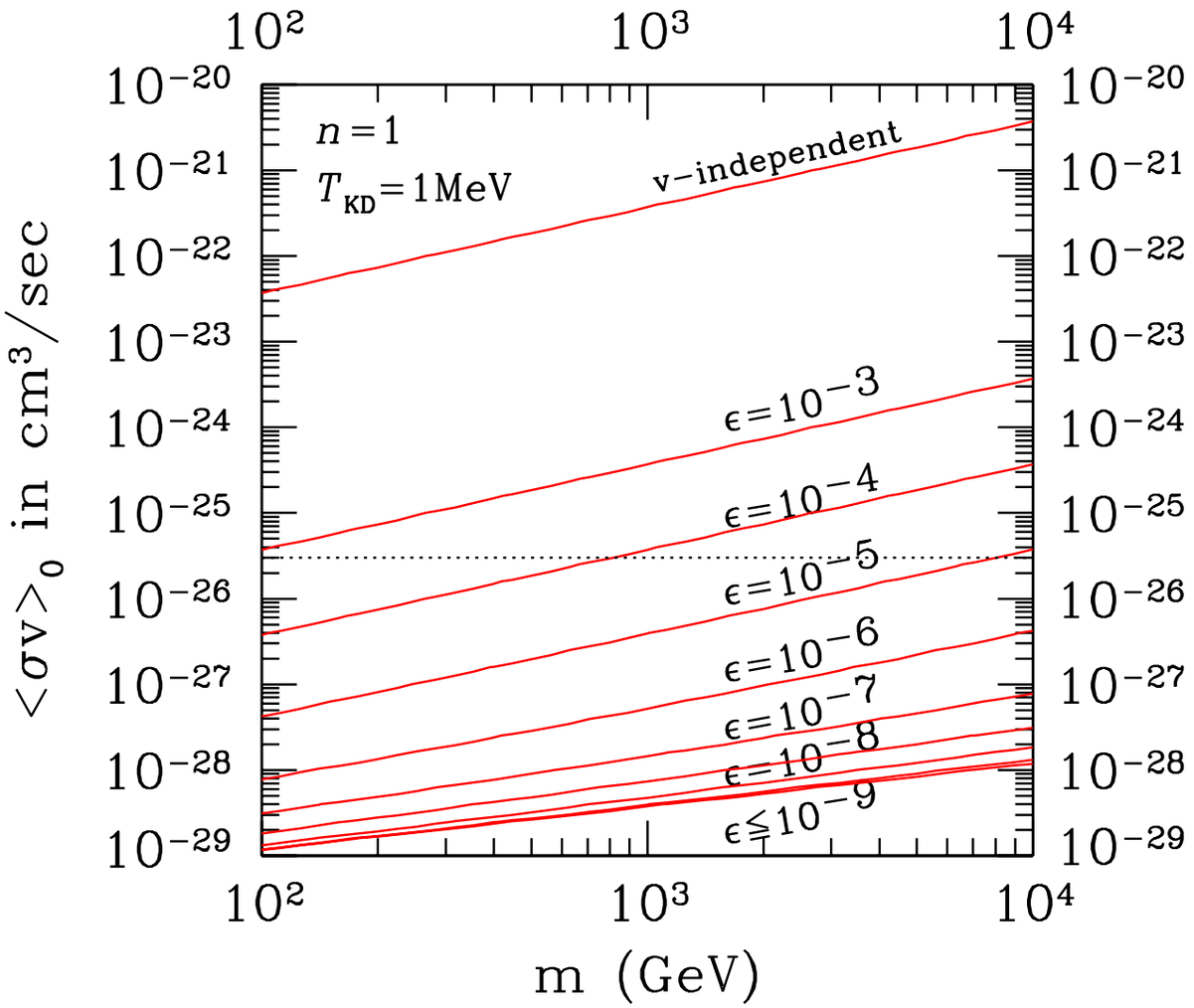
  - Sommerfeld enhancement (n=1)
  - Breit-Wigner enhancement (n=2,4)
- Larger cross section at BBN epoch and after recombination

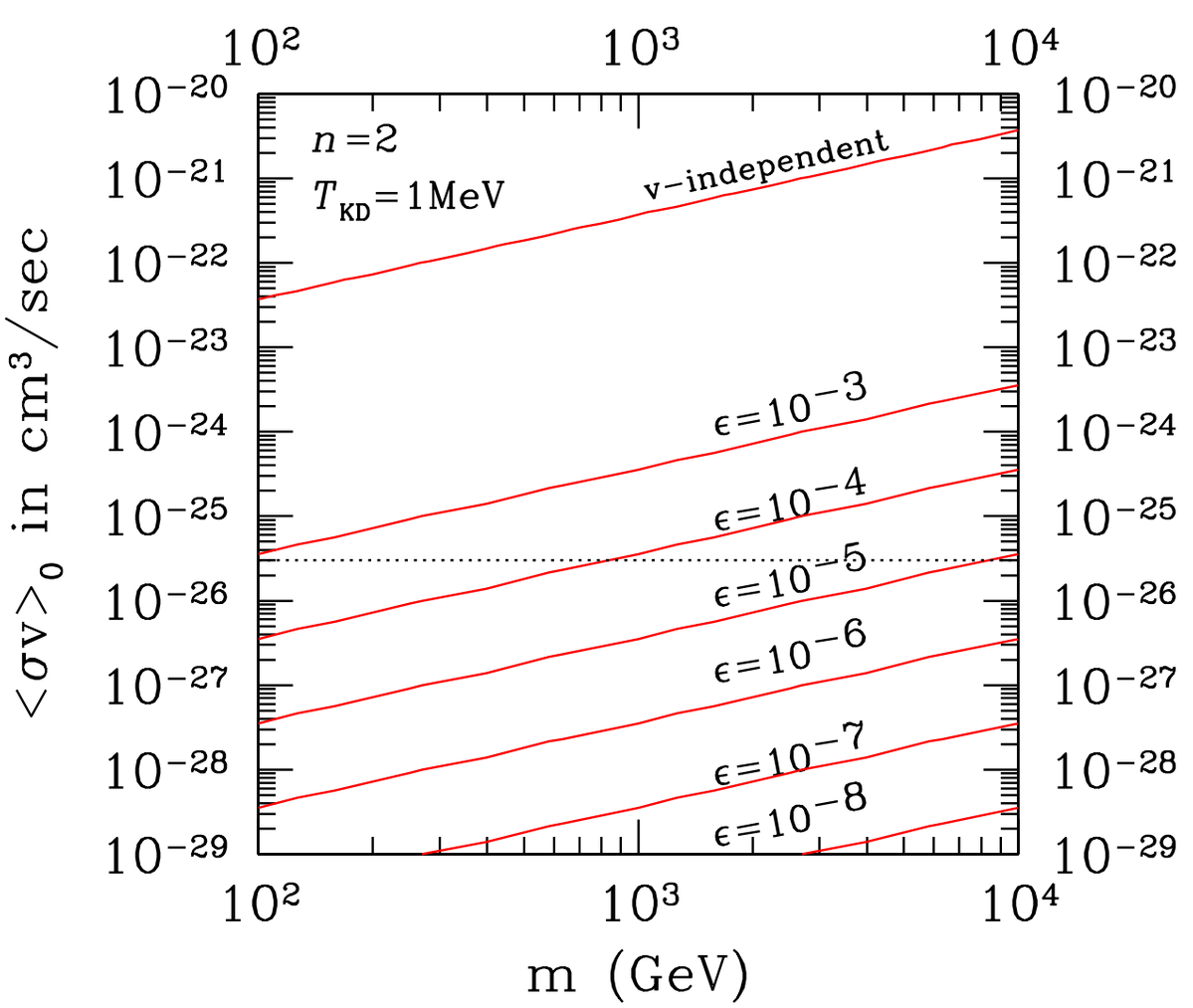
constraints from BBN and CMB

BBN constraint

- Annihilate into electrons/photons

  stringent constraint from He3/D

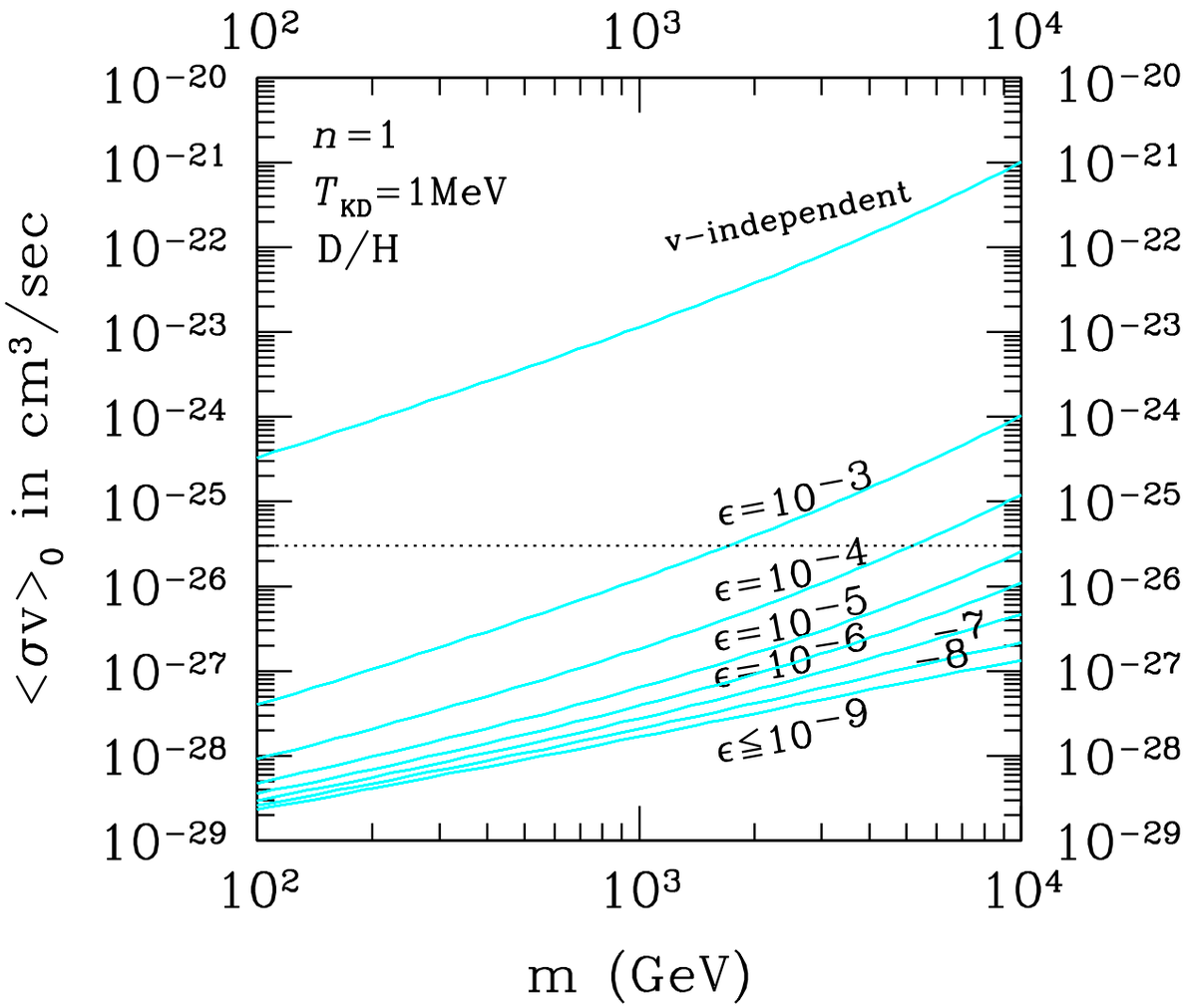


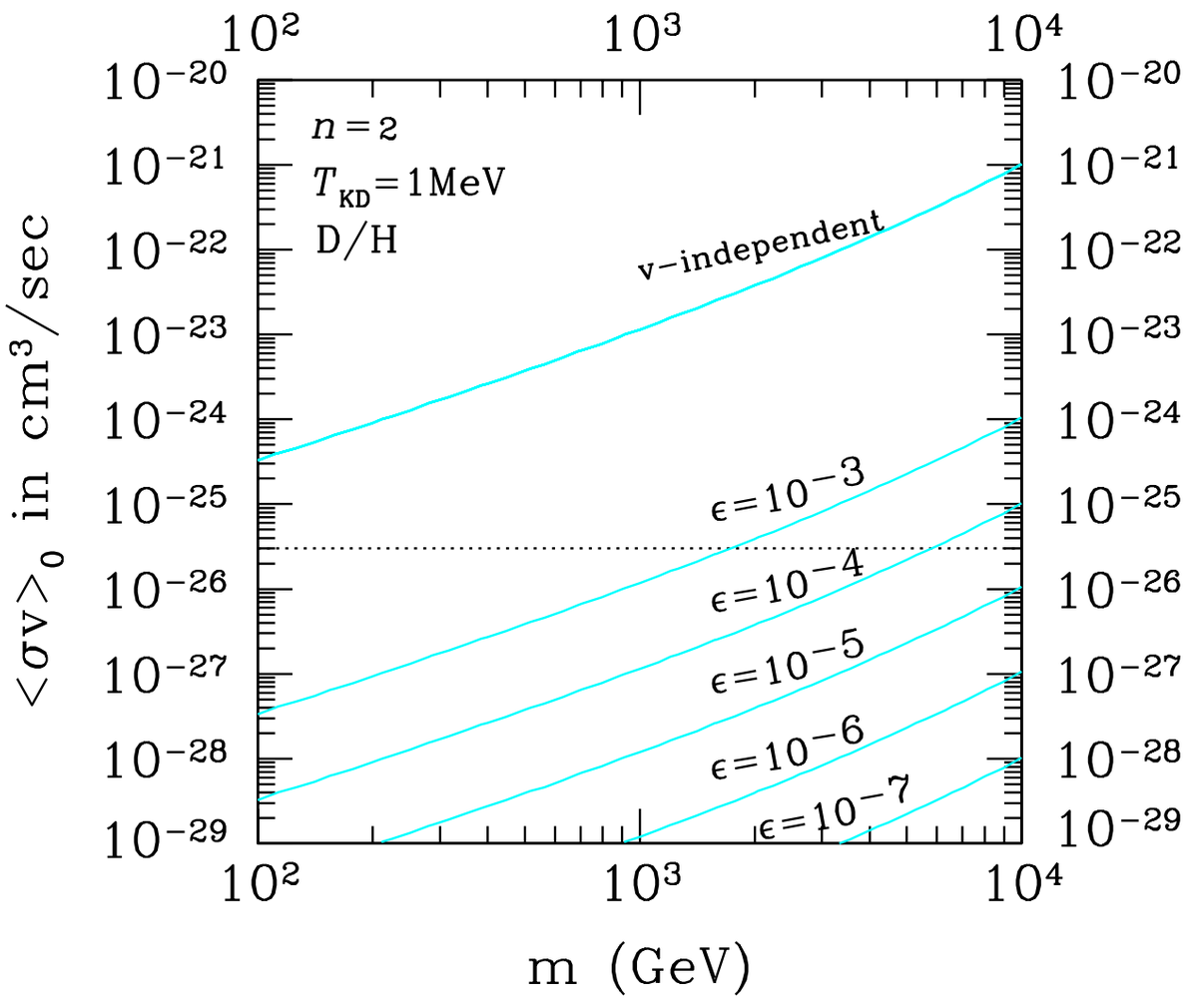


BBN constraint

- Annihilate into $W^{\pm}$ pairs

  stringent constraint from D/H



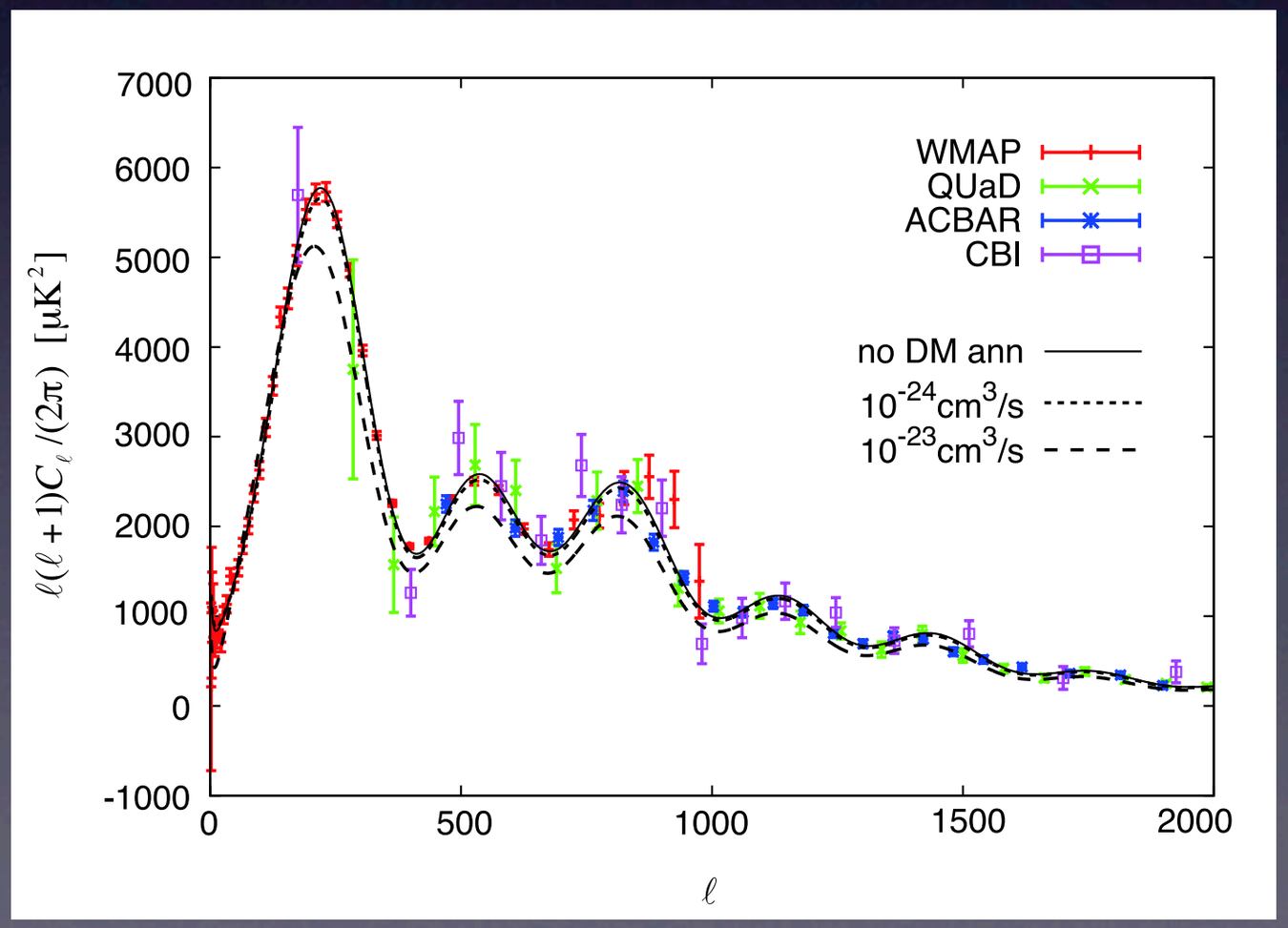


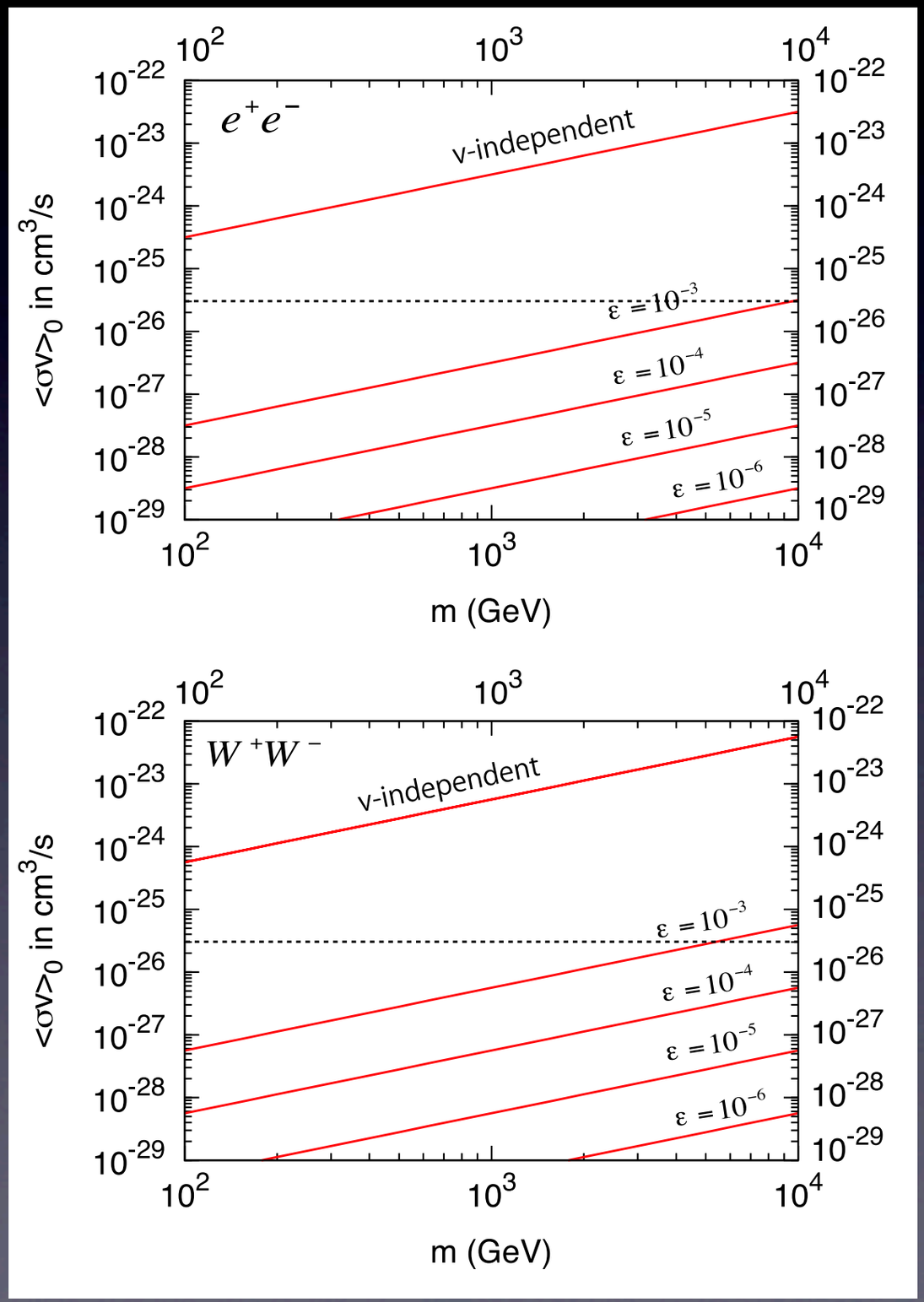
CMB constraint

- High energy electrons and photons may change ionization history of the universe

→ larger optical depth for Thomson scattering

→ smaller CMB anisotropies





Conclusion

- Stringent constraints on velocity-dependent annihilation cross section of dark matter
- CMB constraint is more severe if dark matter annihilates into leptons and photons
- BBN also gives a stringent constraint if dark matter annihilates into hadronic particles
- Thermal relic scenario requires O(1000) enhancement, but it is excluded if $m < O(1)$TeV