# Sommerfeld Enhancement for neutralino Dark Matter

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# Supersymmetric dark matter

In the MSSM the LSP is stable and is a WIMP type dark matter candidate.

Neutralino: mixture of 4 Majorana fermions: $\tilde{H}_u^0, \tilde{H}_d^0, \tilde{W}^0, \tilde{B}$
Chargino: mixture of 4 Majorana fermions: $\tilde{H}_u^+, \tilde{H}_d^-, \tilde{W}^+, \tilde{W}^-$ and form two Dirac fermions.

Two common limits:

- Pure Higgsino: $\tilde{H}_u^0, \tilde{H}_d^0, \tilde{H}_u^+, \tilde{H}_d^-$ form a doublet of Dirac fermions $\mathrm{DM}^+, \mathrm{DM}^0$. Relic mass $M = 1$ TeV.
- Pure Wino: $\tilde{W}^+, \tilde{W}^0, \tilde{W}^-$ form a triplet of Majorana fermions. Relic mass $M = 2.1$ TeV.

# Chargino - Neutralino mass splitting

The mass splitting is

$$\delta M = M_{\mathrm{DM}^{\pm}} - M_{\mathrm{DM}^{0}}$$

and has important phenomenological consequences

- Direct detection
- LHC searches

The mass splitting has two main sources:

- EW corrections, Higgsino: 355 MeV, Wino: 165 MeV
- SUSY corrections (parameters dependent)

# Sommerfeld enhancement

When the velocity $v$ is small, higher powers of $\frac{\alpha}{v}$ become important. In Feynman diagram language, they correspond to ladder diagrams .

They are resummed by computing in QM the wave-function deformation in the non-relativistic potential.

SE is sensitive to the mass splitting $\delta M$ because the neutral pair can flip to a charged pair via $W^{\pm}$ exchange.

Results:

- Higgsino $M = 1$ TeV $\rightarrow$ $M = 1$ TeV, within indirect detection bounds.
- Wino $M = 2.1$ TeV $\rightarrow$ $M = 2.7$ TeV, excluded by indirect detection $\mathrm{DM}^0\mathrm{DM}^0 \rightarrow WW, ZZ$.

# Sommerfeld enhancement

Example: 2.7 TeV Wino for nominal splitting of $\delta M = 165$ MeV.

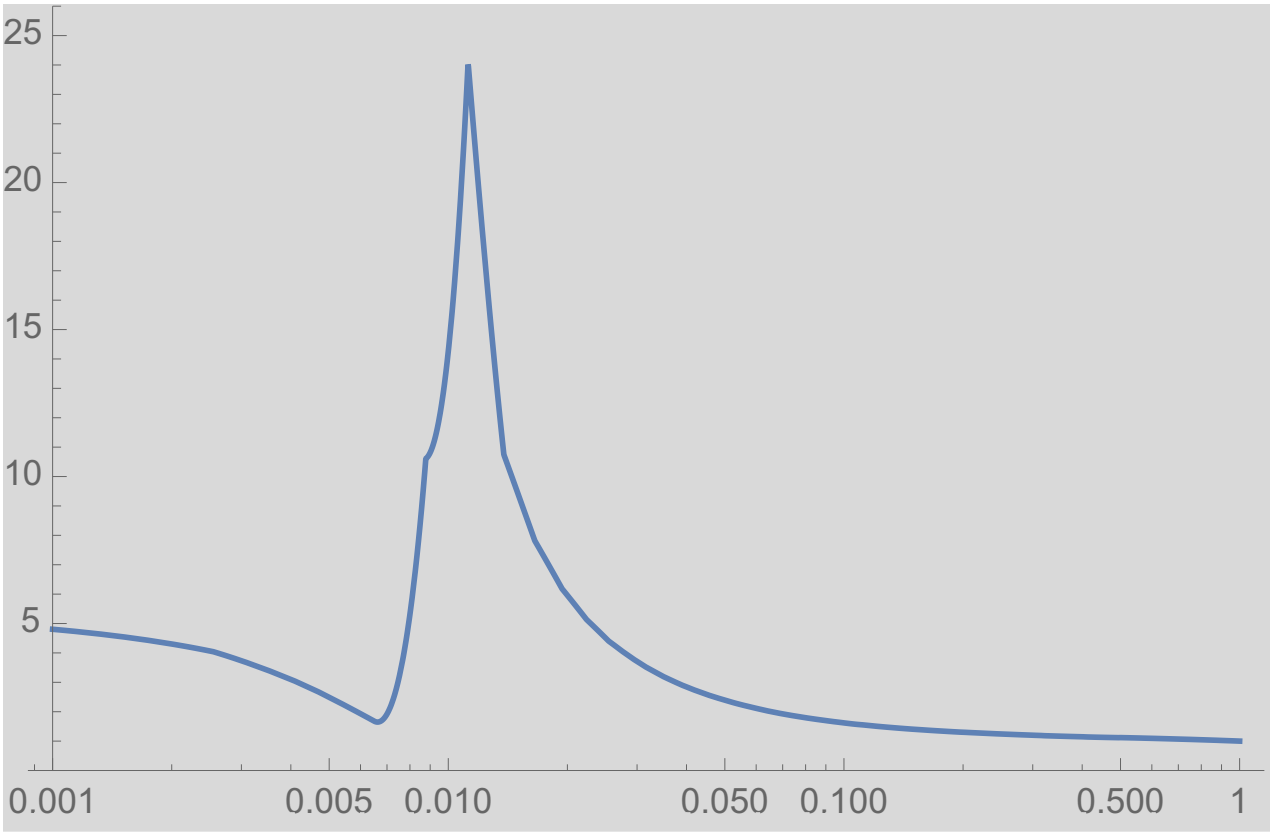


Figure: SE annihilation cross-section normalized to the tree-level cross-section against com velocity.

# Results

Can we change the phenomenology of the pure Higgsino/Wino DM by decreasing the splitting $\delta M$ ?

- The relic mass is insensitive to the splitting: Higgsino stay at 1 TeV and Wino at 2.7 TeV.
- Indirect detection is sensitive to the splitting: Higgsino excluded in a small window $\delta M = 8.5 - 9.5$ MeV.
- Maybe the Wino can evade the idirect detection bounds for lower splitting (in progress)