

Self-interacting dark matter as a solution to the problems in small-scale structures

Camilo Garcia Cely, ULB



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Challenges to the Λ CDM model at small scales

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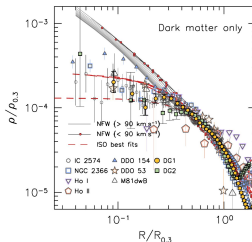
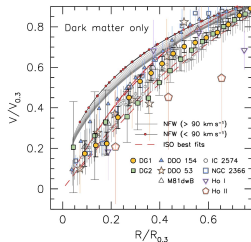
Core vs. cusp problem

dwarf galaxies exhibit a core
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Moore (1994)

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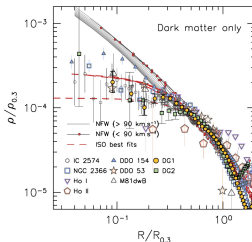
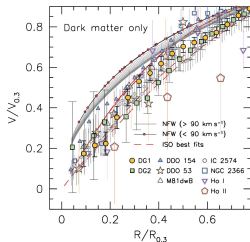
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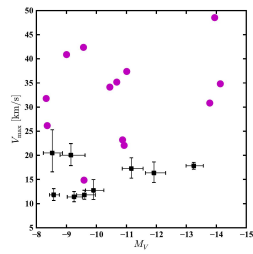
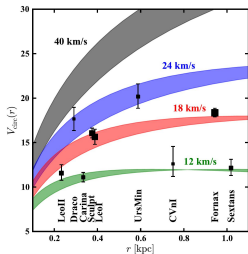
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Too big to fail problem

simulations of the Milky Way
predict subhalos too massive and
too dense to host the brightest
observed satellites

Boylan-Kolchin et al.(2011)

Ferrero et al. (2014)



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- Including baryons on the simulations
- Supernova feedback
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SIDM as a plausible solution

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Simulations show that this is indeed a solution

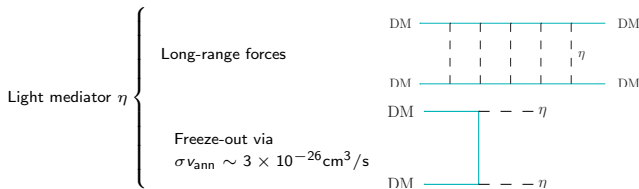
Wandelt, et.al (2000), Vogelsberger et.al (2012)

Peter et.al (2012), Rocha et.al (2013), Zavala et.al (2012)

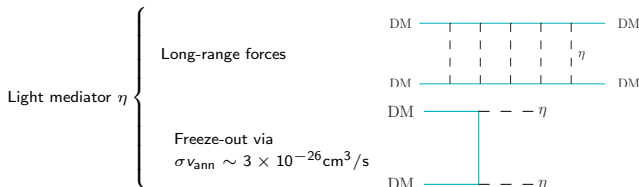
Elbert et.al (2014), Kaplinghat (2015), Vogelsberger et.al (2015)

Francis-Yan Cyr-Racine (2015)

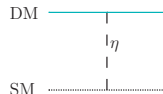
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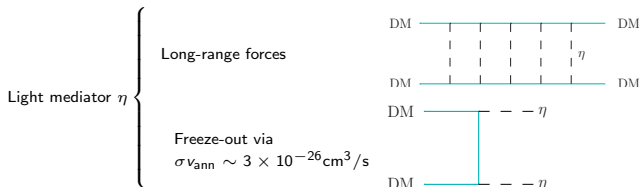


Implementing the freeze-out is **challenging** because thermal equilibrium between the SM and DM is needed, which leads to problems [Bernal, Chu, CGC, Hambye, Zaldivar \(2015\)](#)

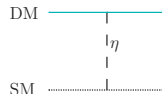


- In the early universe the mediator is produced in large amounts affecting the CMB and BBN.
- Large direct detection rates. [Kaplinghat, Sean Tulin, Yu \(2013\)](#)
- Large annihilation signals due to the Sommerfeld effect. [Brignmann, Kahlhoefer, Schmidt-Hoberg, Walia \(2016\)](#)
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DM annihilations (freeze-out)

DM self-interactions (small structures)

Portals to the SM



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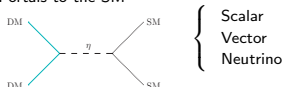
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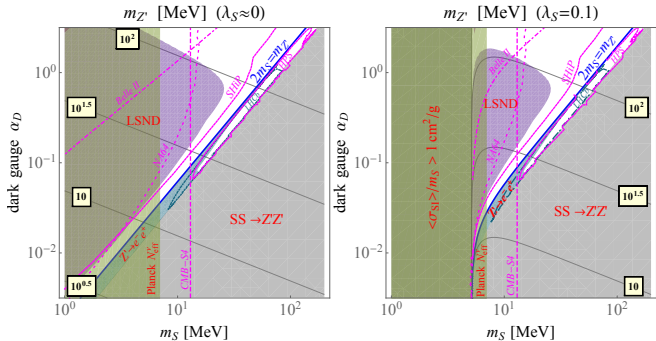
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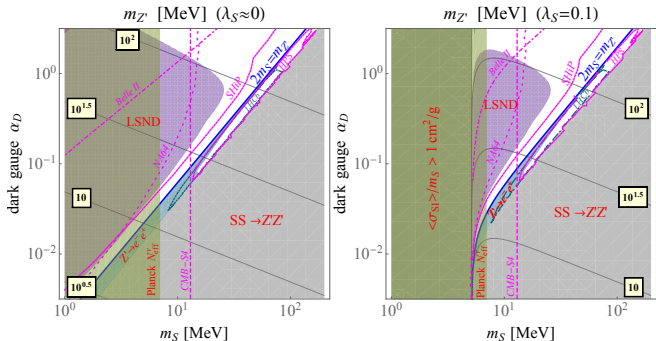
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Freeze-out: Scalar DM coupled to a heavier Z'



- Five parameters: λ_S , the kinetic mixing ϵ , $M_{Z'}$, M_S and α_D . The freeze-out via $SS \rightarrow Z' \rightarrow f_{SM} \overline{f_{SM}}$ and the self-interaction hypothesis constrain two of them.
- Annihilations into fermions are p-wave suppressed. No annihilation into photons.
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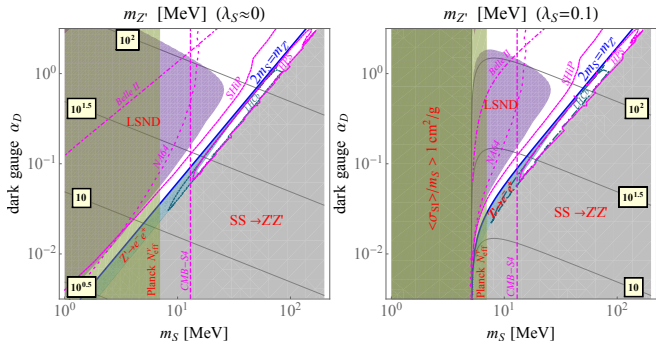


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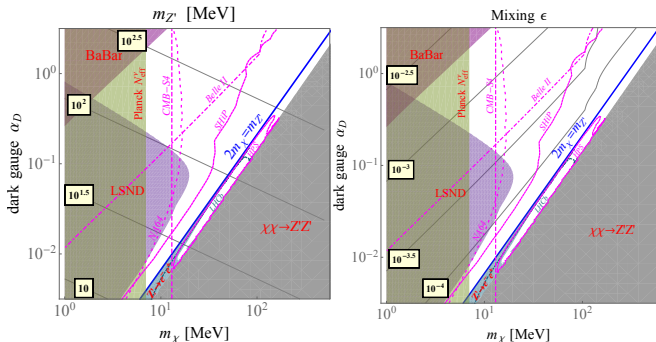
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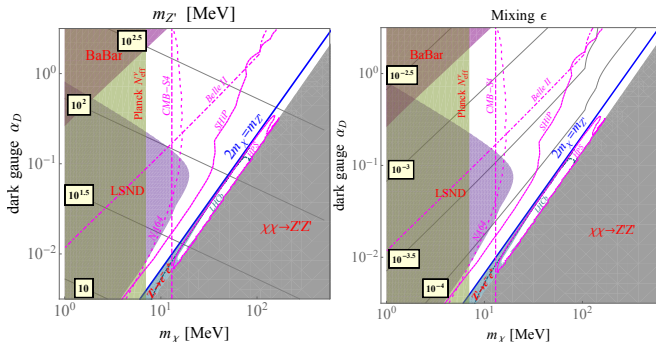
Essig, Fernandez-Serra, Soto, Volansky, T.-T. Yu (2016)

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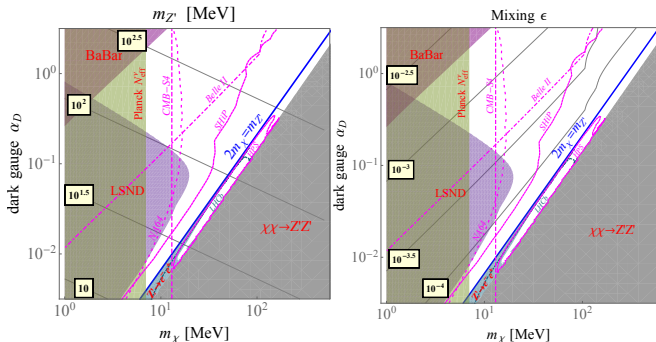


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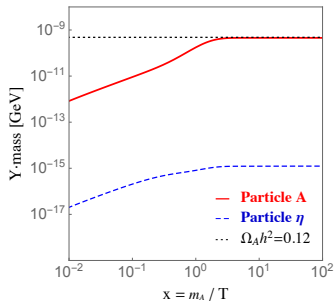


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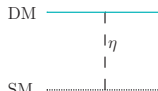
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- Model building is required because there must be a dark scalar close in mass to the Z' .

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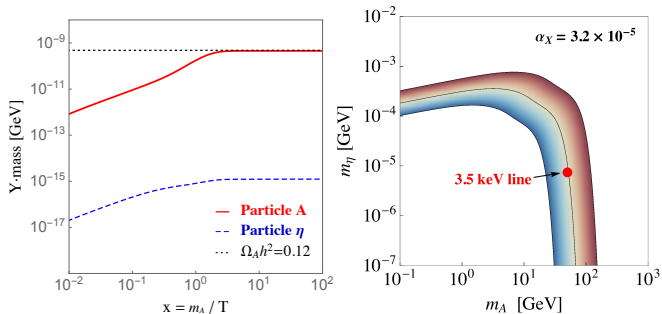


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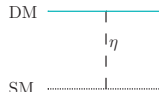


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Thanks for your attention!