

The nature of dark matter

WIMPs and beyond

Jan Heisig

Chargé de
recherches

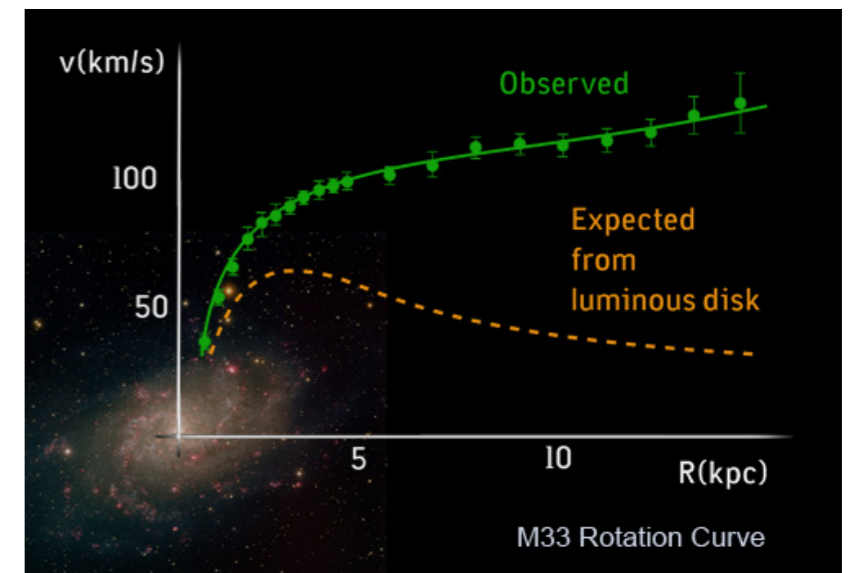
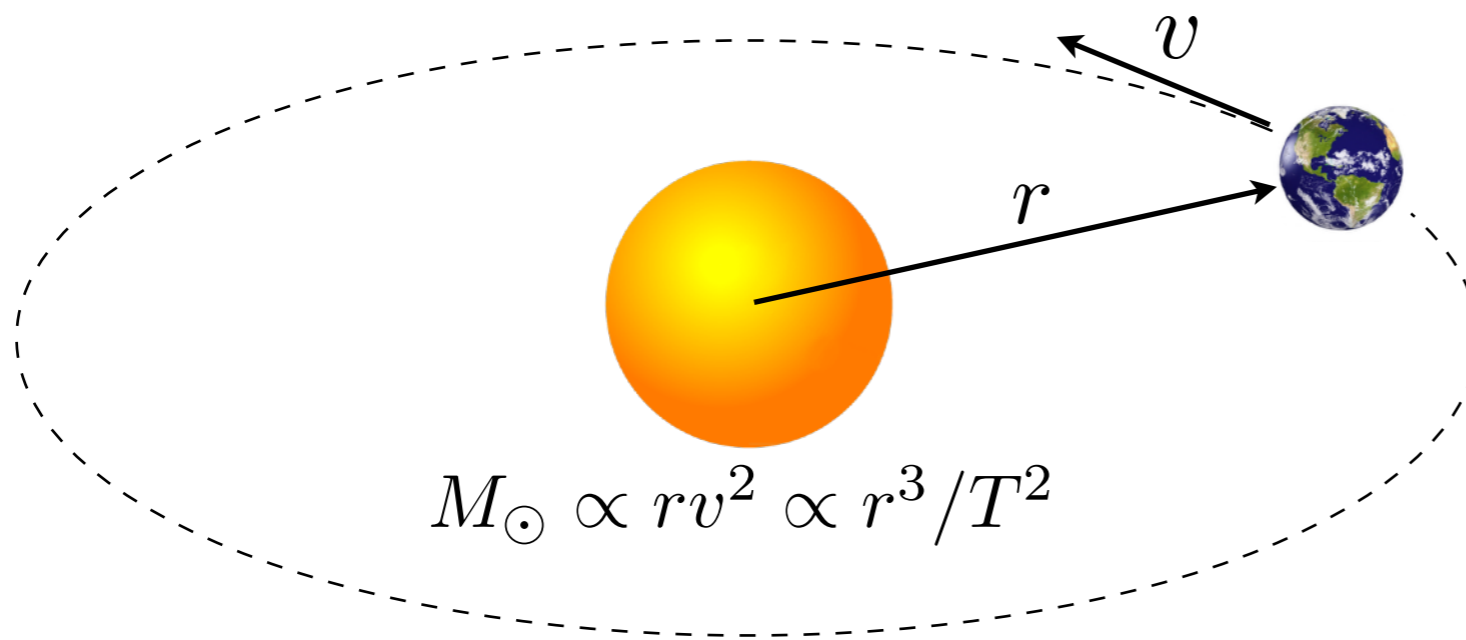


When the M meets the P at IRMP

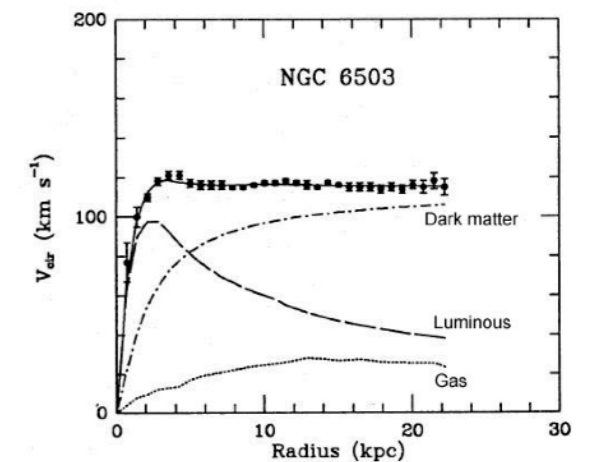
UCL, December 13, 2018

The phenomenon of Dark Matter

- More matter than visible one
- gravitational effect on dynamics of visible matter, e.g. in rotation curves
- similar to determination of solar mass:

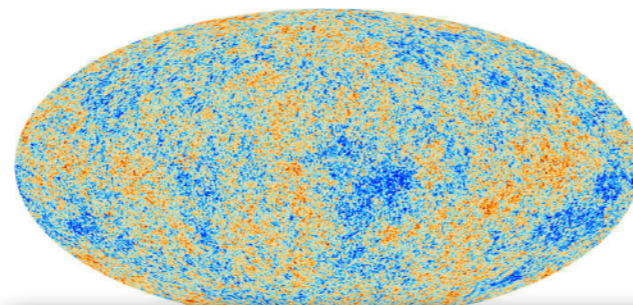
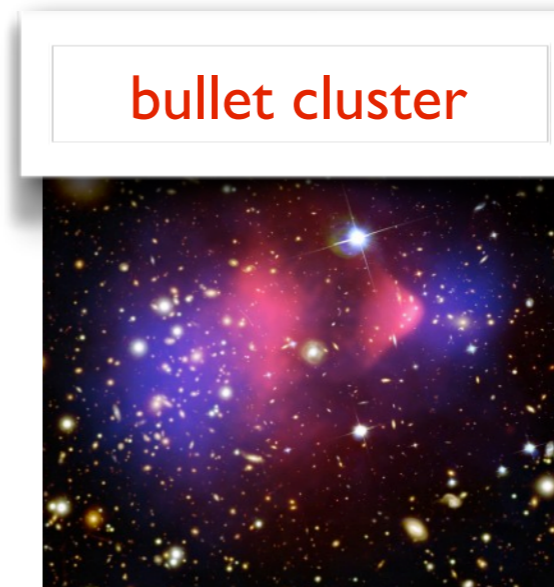
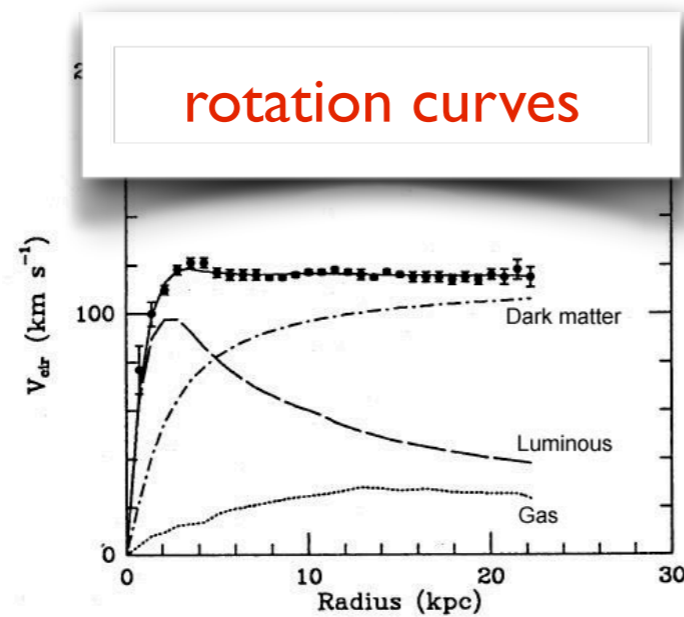


[M33 Image: NOAO, AURA, NSF, T.A.Rector]



The phenomenon of Dark Matter

- Present on very different length scales



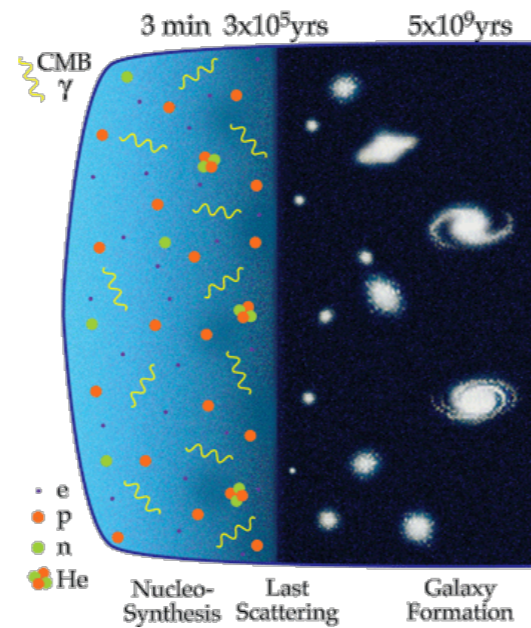
CMB anisotropies



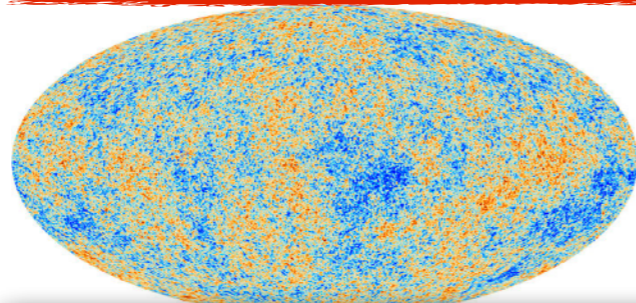
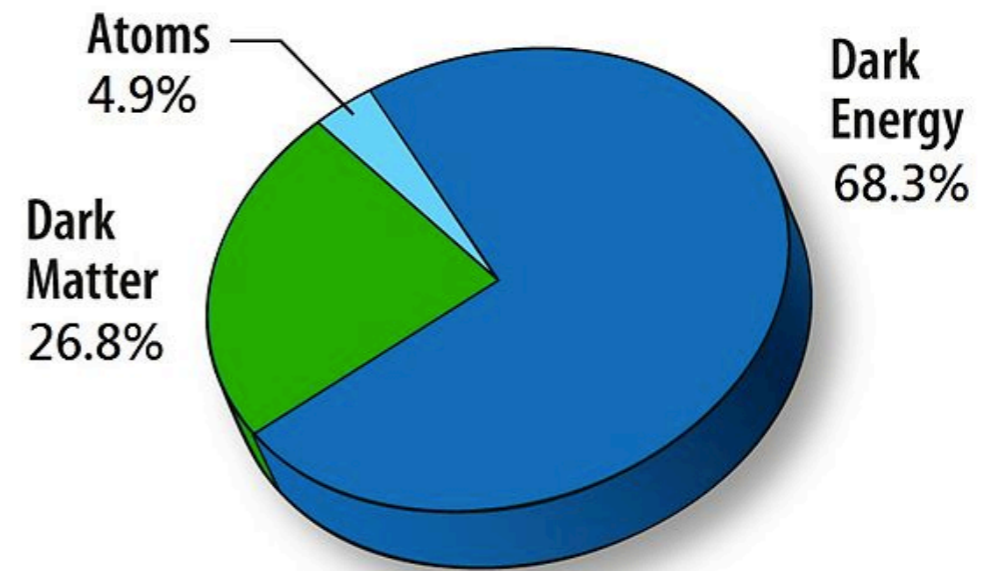
grav. lensing

The phenomenon of Dark Matter

- Present on very different length scales



Contributions Ω_i to the energy density of the Universe today:



CMB anisotropies

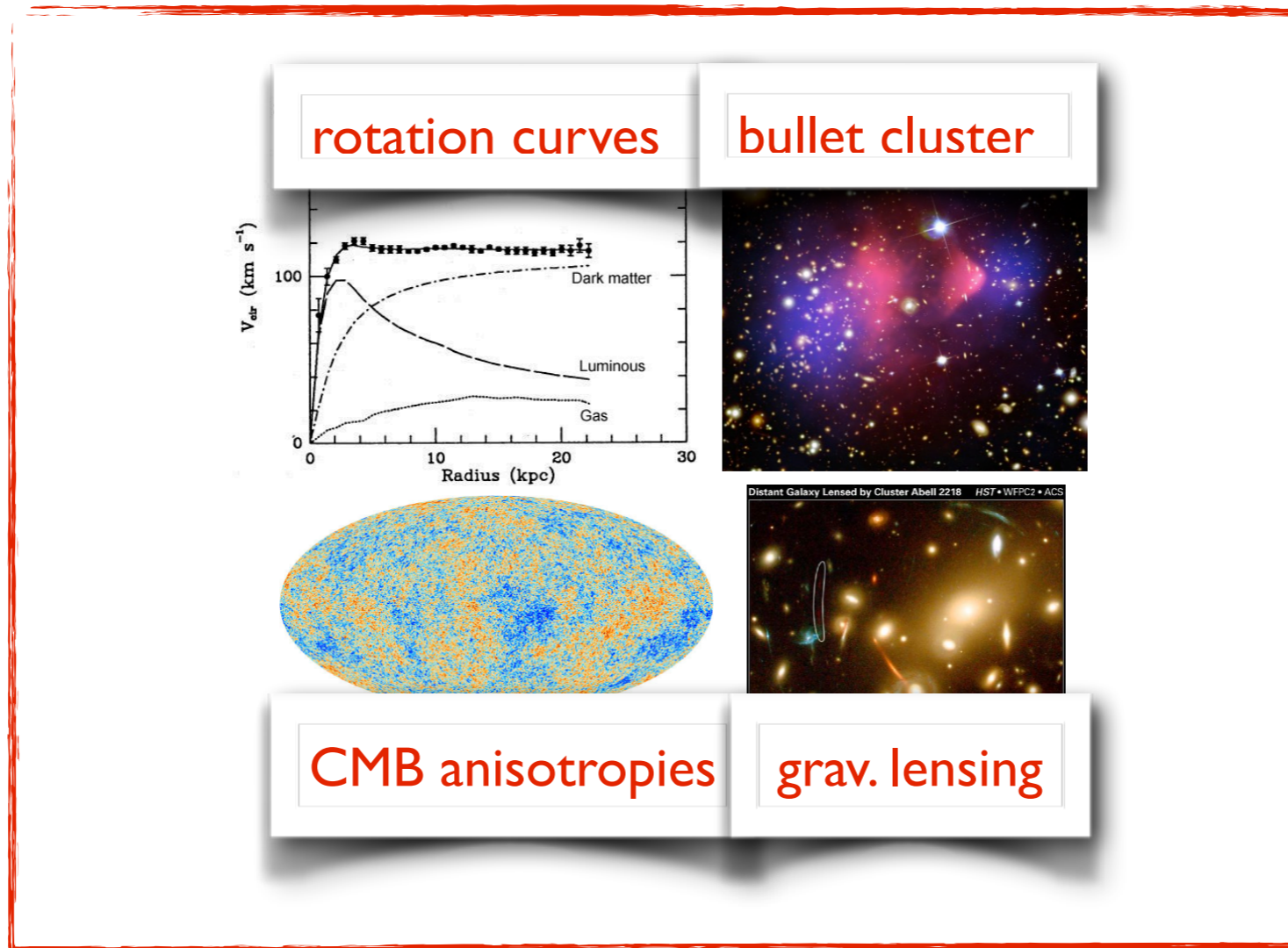
TODAY

[Planck 2015]

$\Omega_{\text{DM}} h^2 = 0.1198 \pm 0.0015$

Particle Dark Matter

Explain appearance on all scales:
Most plausible \rightarrow new particle



Particle Dark Matter

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Most plausible → new particle



How to get the right relic density?

$$\Omega_{\text{DM}} h^2 = 0.1198 \pm 0.0015$$

Particle physics
+Early Universe cosmology
+Thermodynamics

$$E_{\chi} (\partial_t - H p \partial_p) f_{\chi}(p, t) = C [f_{\chi}]$$

How to detect it?
Further interactions?

LHC, direct/indirect detection, ...

Collider phenomenology,
astroparticle physics

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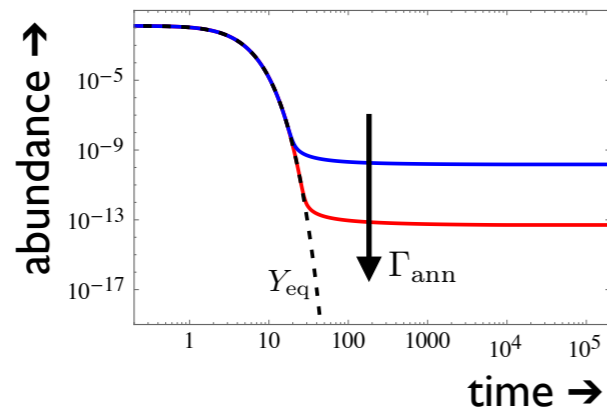
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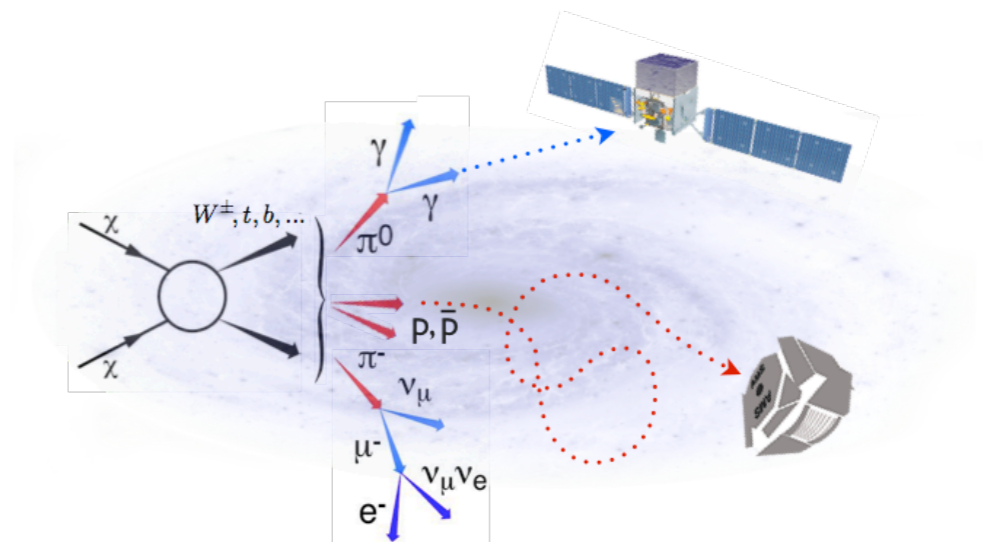
Weakly interacting massive particles (WIMPs)

- Possible link to electroweak scale physics (e.g. supersymmetry)
- Sizeable (weak) coupling

Relic density:
WIMP freeze-out
mechanism



Detection:
e.g. indirect detection



[e.g. 1704.08258, 1711.05274]

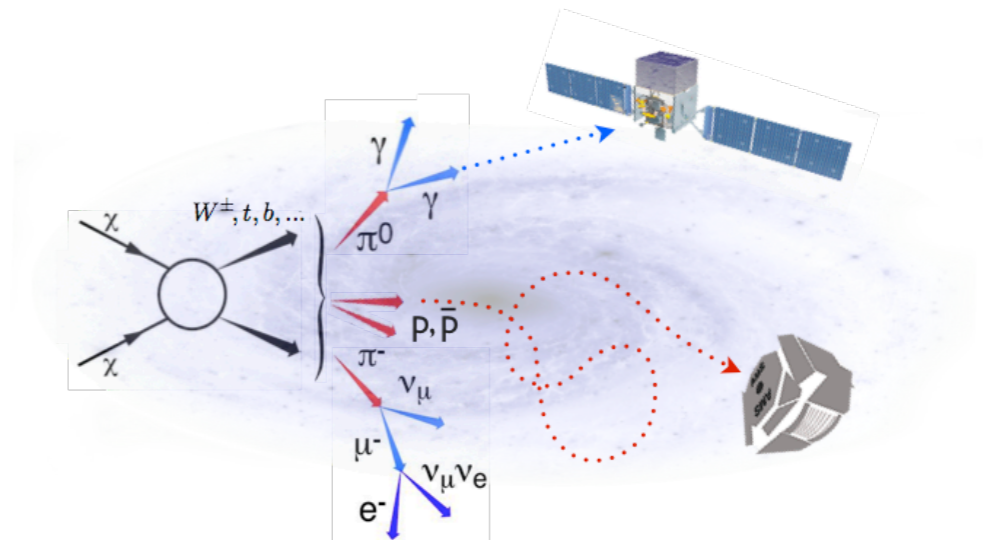
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CP3 seminar
on Thursday, January 10th

[e.g. 1704.08258, 1711.05274]

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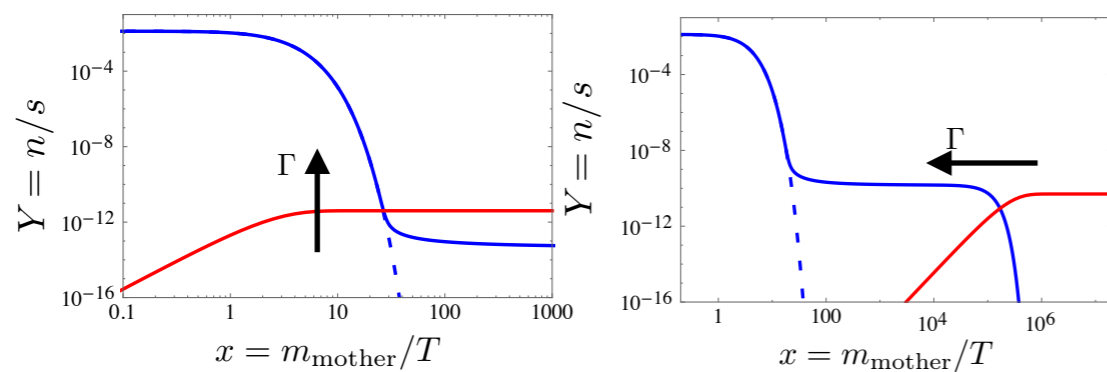
Dark matter beyond WIMPs

- (Partly) decoupled dark sectors

Conversion-driven
freeze-out

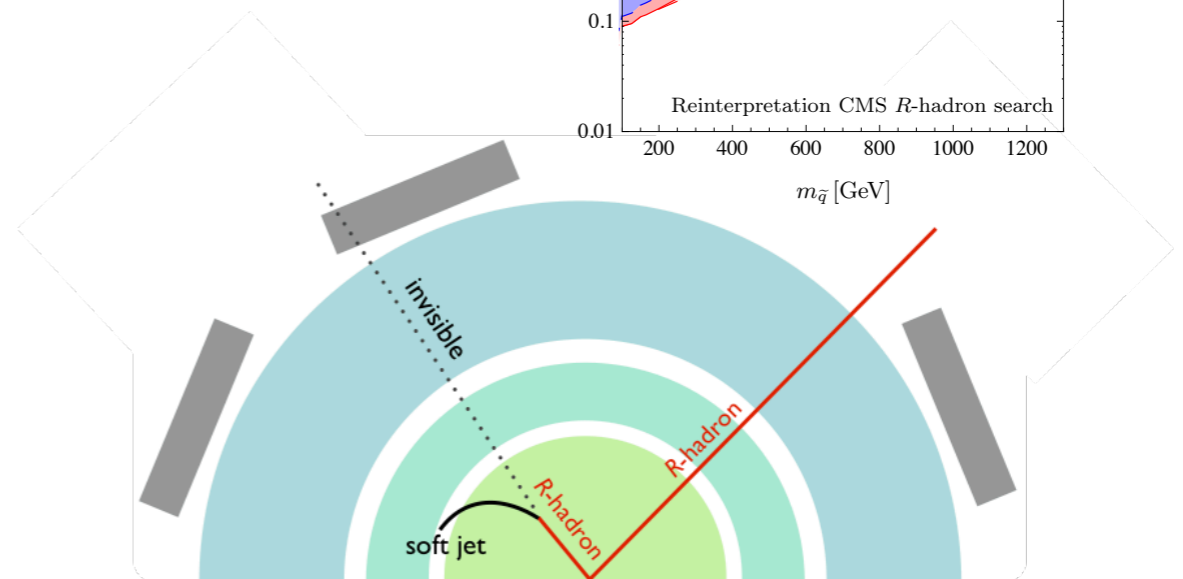
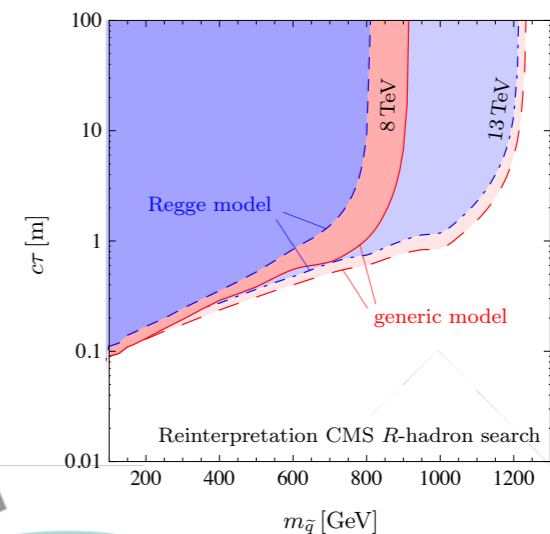
Freeze-in, superWIMP
mechanism

[e.g. 1705.09292, 1809.10135]



Detection:

e.g. long-lived particles



[e.g. 1509.00473, 1808.05229]

Phenomenological studies

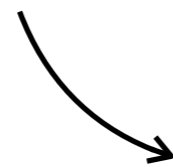
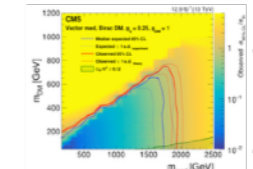
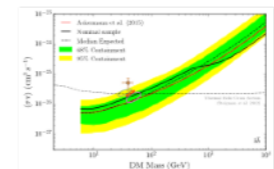
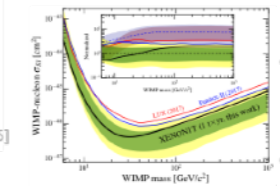
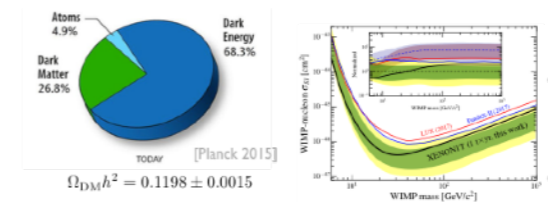
- Flexible and reliable numerical tools needed

Model

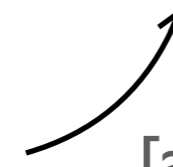
$$\mathcal{L} = -\frac{1}{4}F^{\mu\nu}F_{\mu\nu} + i\bar{\Psi}(\not{D} - m)\Psi + (D^\mu\phi)^*D_\mu\phi + \dots$$



Experiment



MadDM



[arXiv:1804.00044]

Phenomenological studies

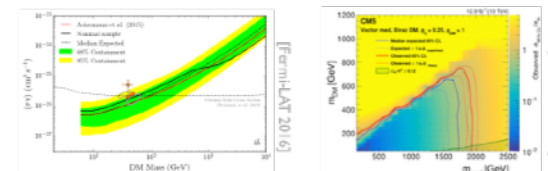
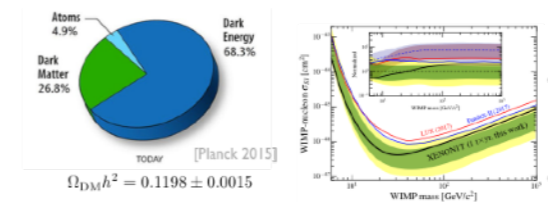
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Experiment



MadDM

[arXiv:1804.00044]

v3.0: indirect detection

future: beyond WIMPs



Thank you!

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