

# Multi-Component Dark Matter in Direct Detection Experiments

Andre Scaffidi

JCAP 1711 (2017), Phys.Rev. D98 (2018), JCAP 1901 (2019)

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In collaboration with Juan Herrero-Garcia, Martin White and Anthony Williams

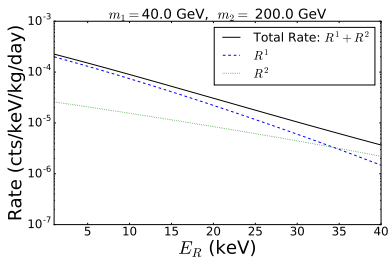
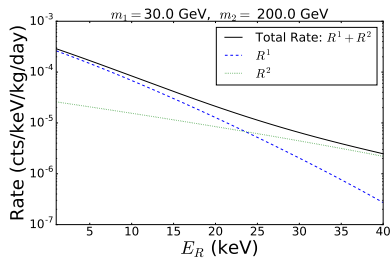
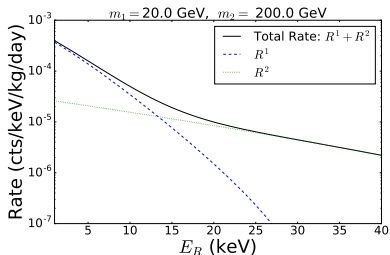
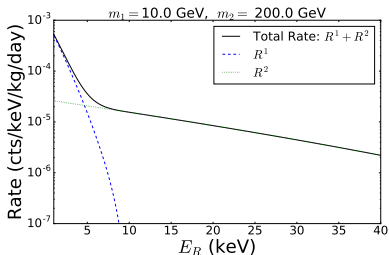
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ARC Center of Excellence for Particle Physics at Terascale,  
The University of Adelaide



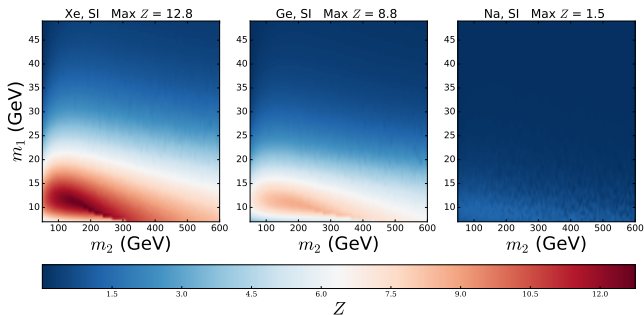
# Minimal multi-component scenario: Two WIMPs

The differential recoil rate for a two-particle spectrum:



# Result (in a nutshell)

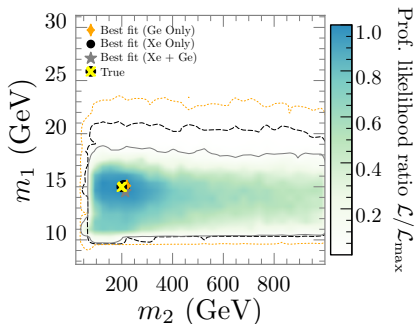
- ▶ Forecast median experimental sensitivity to discriminate between 1DM and 2DM.
- ▶ “Median sensitivity”  $\Rightarrow Z = \sqrt{\mathcal{L}_{\text{Asimov}}^{2DM}} \propto \sqrt{\text{Exposure}}$
- ▶ Mass splitting best discriminator!  $\Rightarrow$  If lightest component of spectrum not  $\lesssim 25$  GeV, no hope of significantly seeing multi-component DM!!



# Explore parameter space for interesting degeneracies

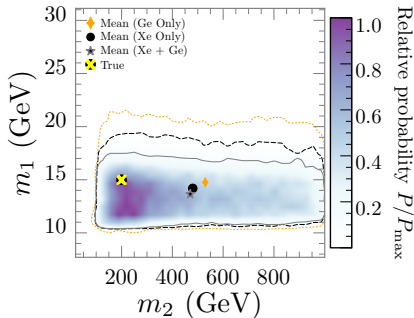
**Frequentist approach:**

$$\lambda(\theta_1, \theta_2) = \frac{\mathcal{L}(\theta_1, \theta_2, \hat{\theta}_3 \dots \hat{\theta}_n | \mathbf{x})}{\mathcal{L}_{\max}(\hat{\theta} | \mathbf{x})}$$



**Bayesian approach:**

$$P(\theta | \mathbf{x}) = \frac{\mathcal{L}(\mathbf{x} | \theta) \cdot \pi(\theta)}{\int d\theta \mathcal{L}(\mathbf{x} | \theta) \cdot \pi(\theta)}$$

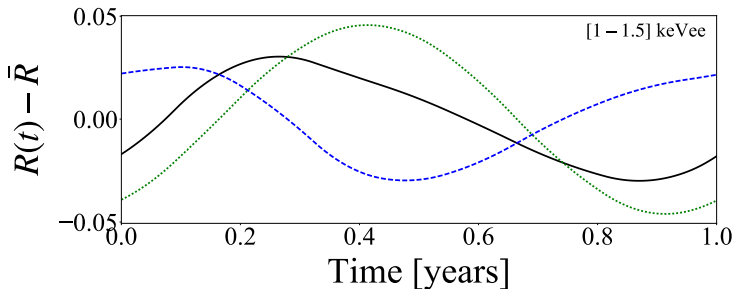


## 2DM in annual modulation

- ▶ Components can anti-modulate  $\Rightarrow$  non-sinusoidal!
- ▶ Non-sinusoidal signals indicative of multiple-components.

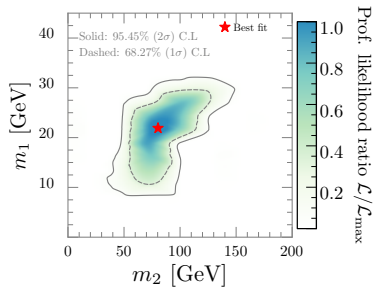
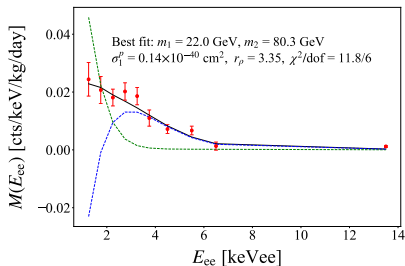
$$\mathcal{M}(t) = \mathcal{M}^{(1)} \cos \left[ 2\pi \left( t - t_0^{(1)} \right) \right] + \mathcal{M}^{(2)} \cos \left[ 2\pi \left( t - t_0^{(1)} - \Delta t_0 \right) \right]$$

GF correction  $\nearrow$



# Test-bed: DAMA/LIBRA

- ▶ Phase-2 data inconsistent with minimal 1-Cpt solution.
- ▶ Bin-by-bin temporal data not provided  $\Rightarrow$  likelihood free approach.
- ▶ Two anti-modulating components reconcile discrepancy with  $p = 0.07$ .



Thank You!