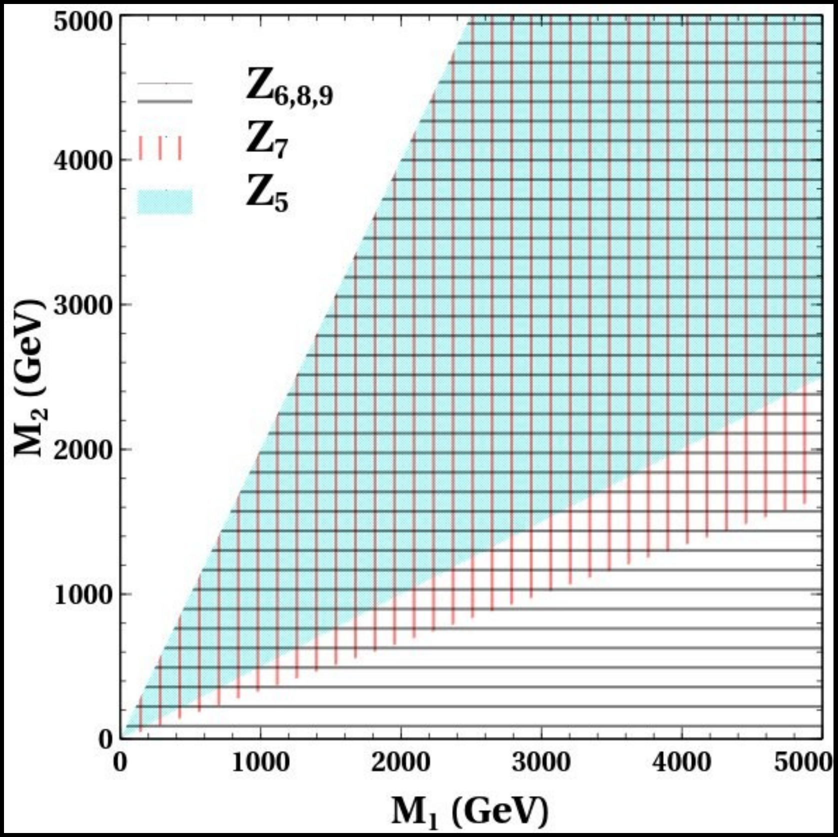
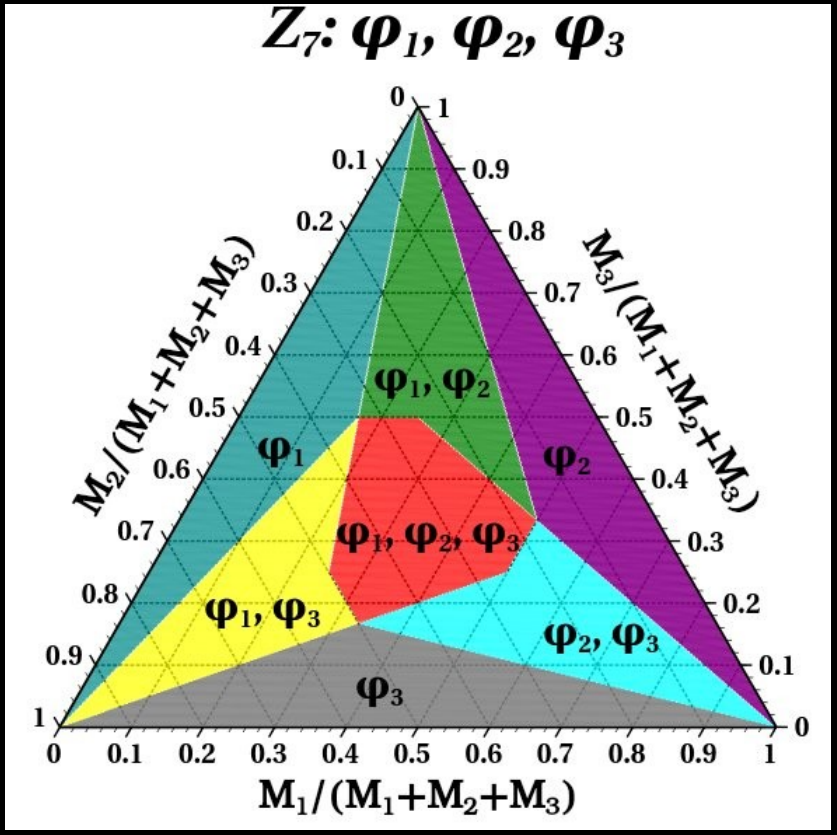
A theoretical framework for multi-component dark matter



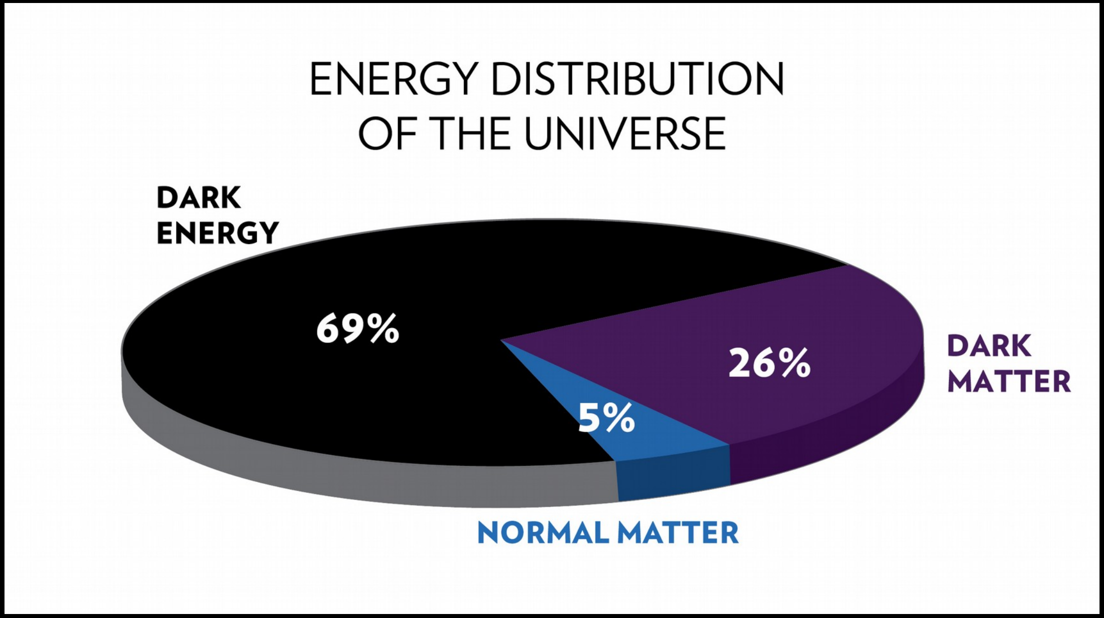


Based on 1911.05515,
with Oscar Zapata

Carlos E. Yaguna
Escuela de Física
UPTC, 2019

The dark matter may consist of several different particles

What has been measured is Ω_{DM}

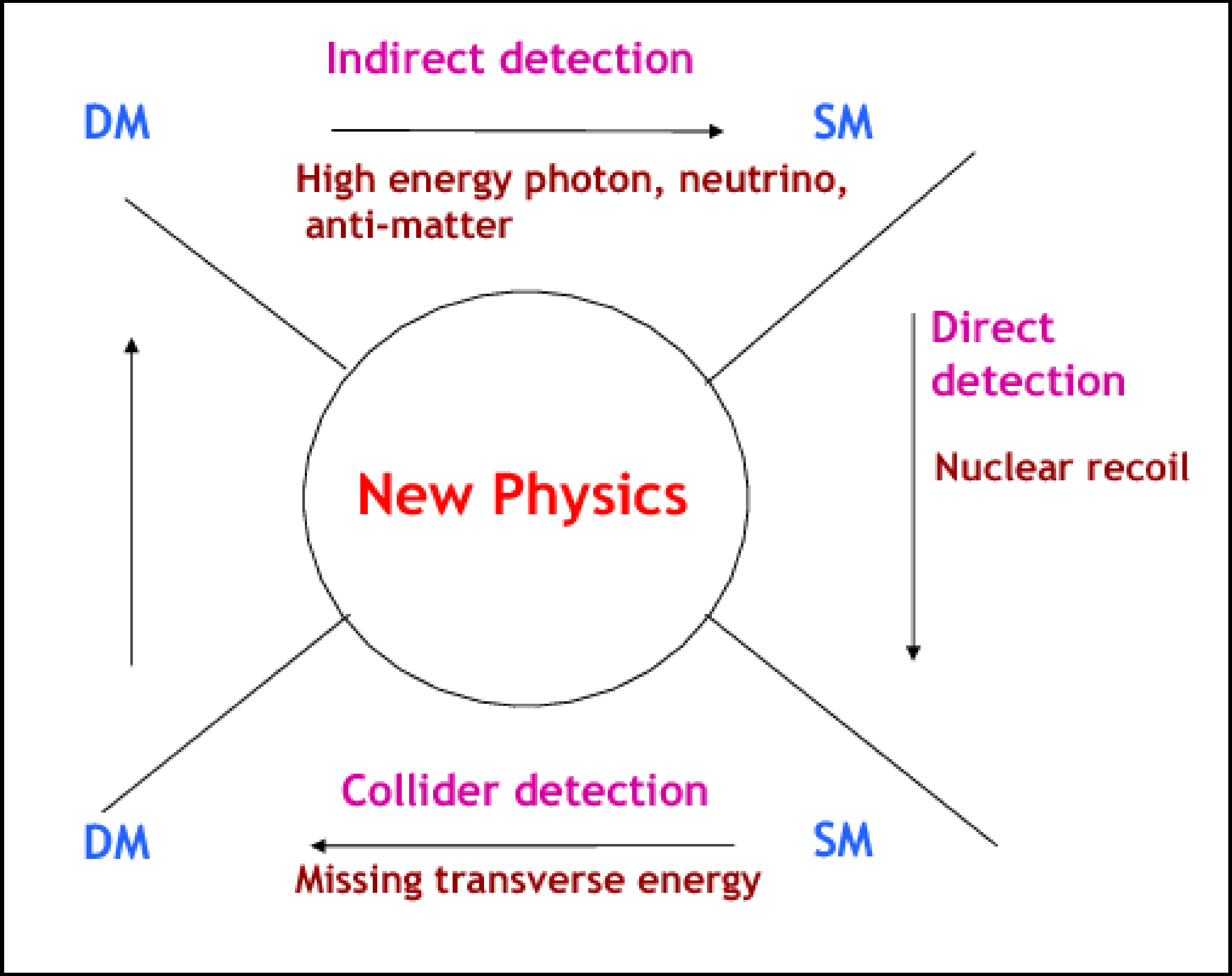


$\Omega_{DM}h^2 = 0.1200 \pm 0.0012$

Ω_{DM} can be explained by several particles

This is called multi-component DM

Multi-component dark matter could be discovered in standard DM searches



But the stability of these different particles is difficult to understand theoretically

For one DM particle a Z_2 symmetry can be used

It's *ad hoc*

With a Z_2 only one particle is stable

The lightest one among the odd

A Z_N can stabilize multiple particles

Battel, 1007.0045

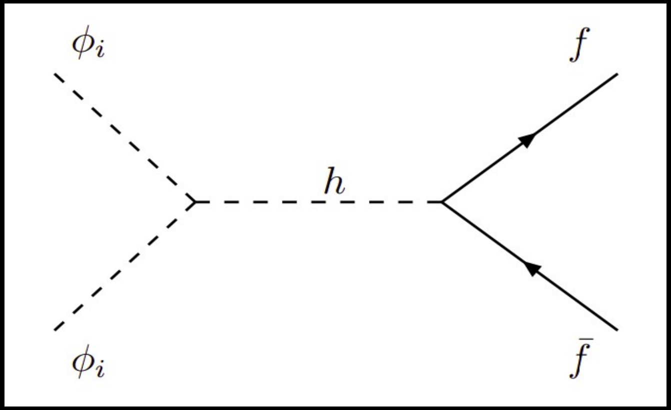
We consider scenarios with several scalar fields charged under a single Z_N

These scalar fields are the DM particles

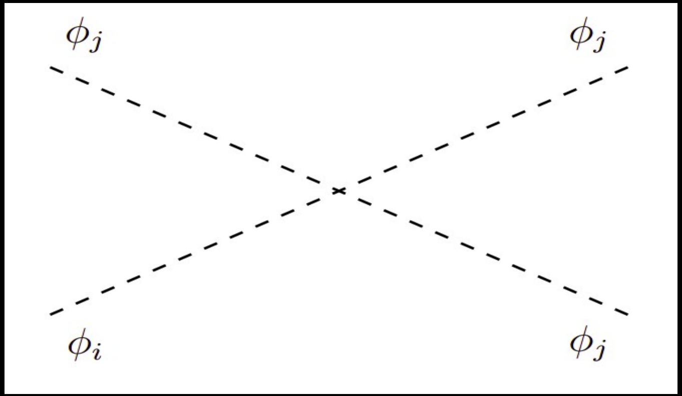
$$1, w, w^2, ..., w^{N-1}, \quad \text{with} \quad w = \exp(i2\pi/N)$$

$$\phi_\alpha \sim w^\alpha, \quad \text{with} \quad \alpha = 1, 2, ..., k, \quad \text{and} \quad k \leq N/2$$

They interact via the Higgs portal



And give rise to novel processes



Models of multi-component DM based on a Z_N symmetry are very interesting

The Z_N symmetry may be a remnant from a U(1)

Related to SM extensions?

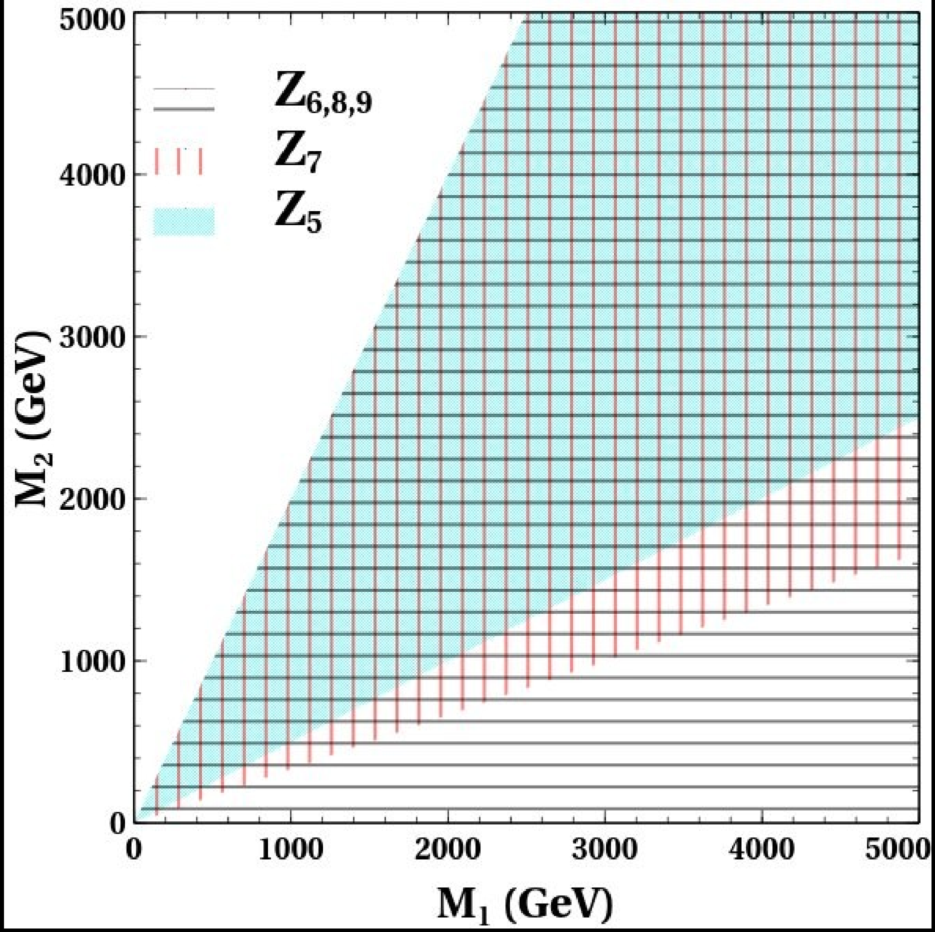
Up to N/2 scalars can be stabilized

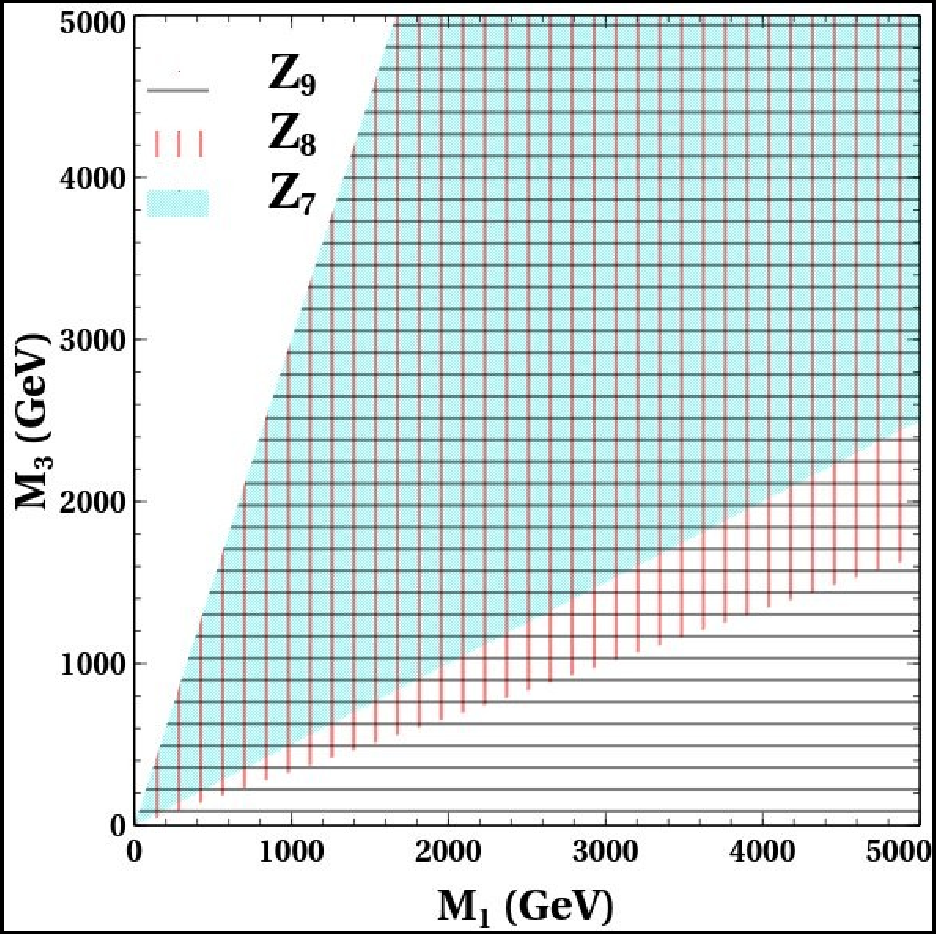
One of them may be real

How many DM particles do we get?

It depends on the masses!!

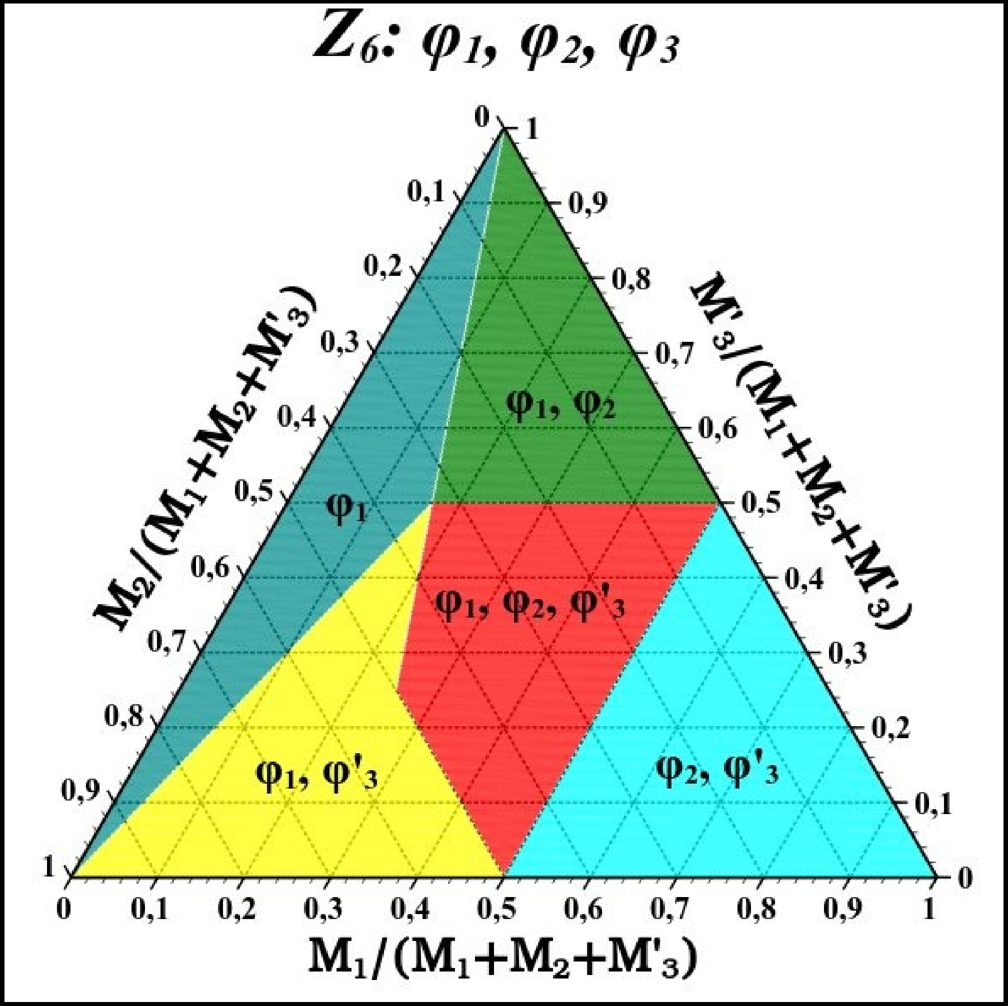
To stabilize two dark matter particles at least a Z_4 is required

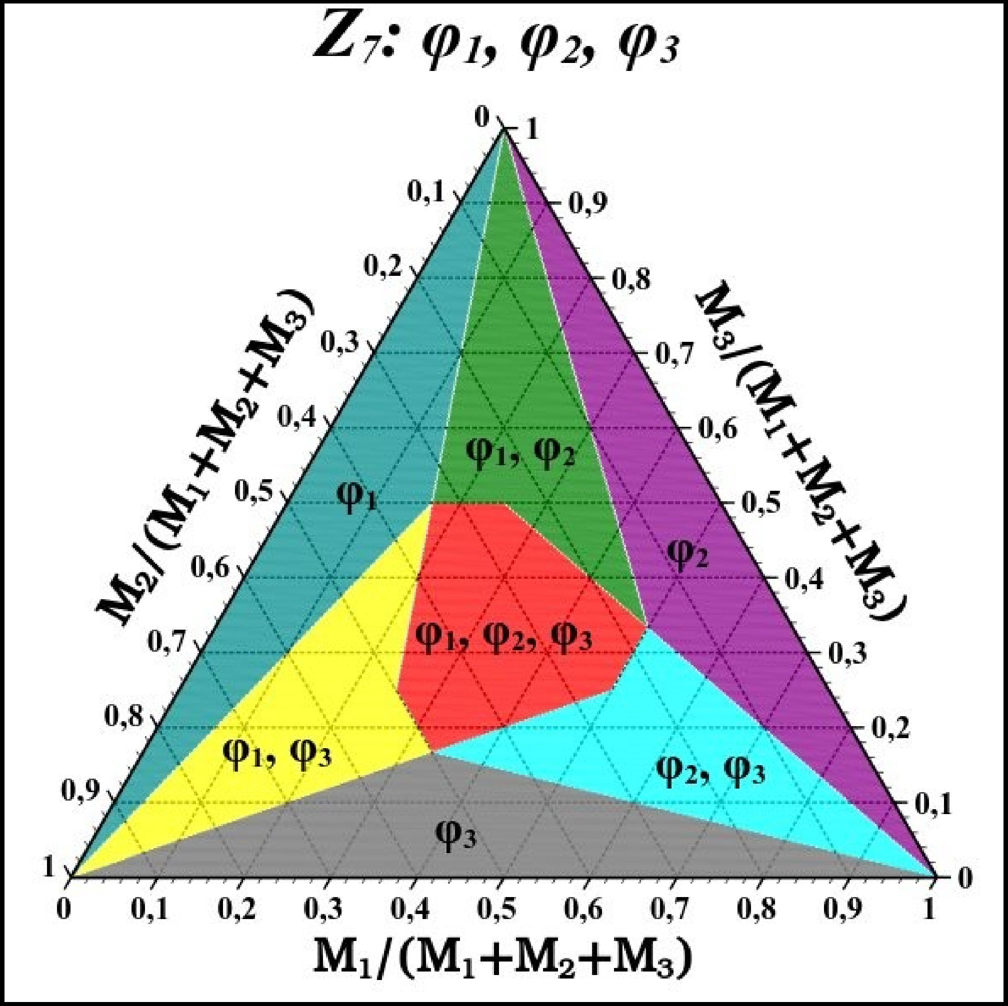




For a Z_6 with fields φ_2, φ_3 it is possible to get *unconditional* stability

For 3 DM particles the stability regions are not so trivial





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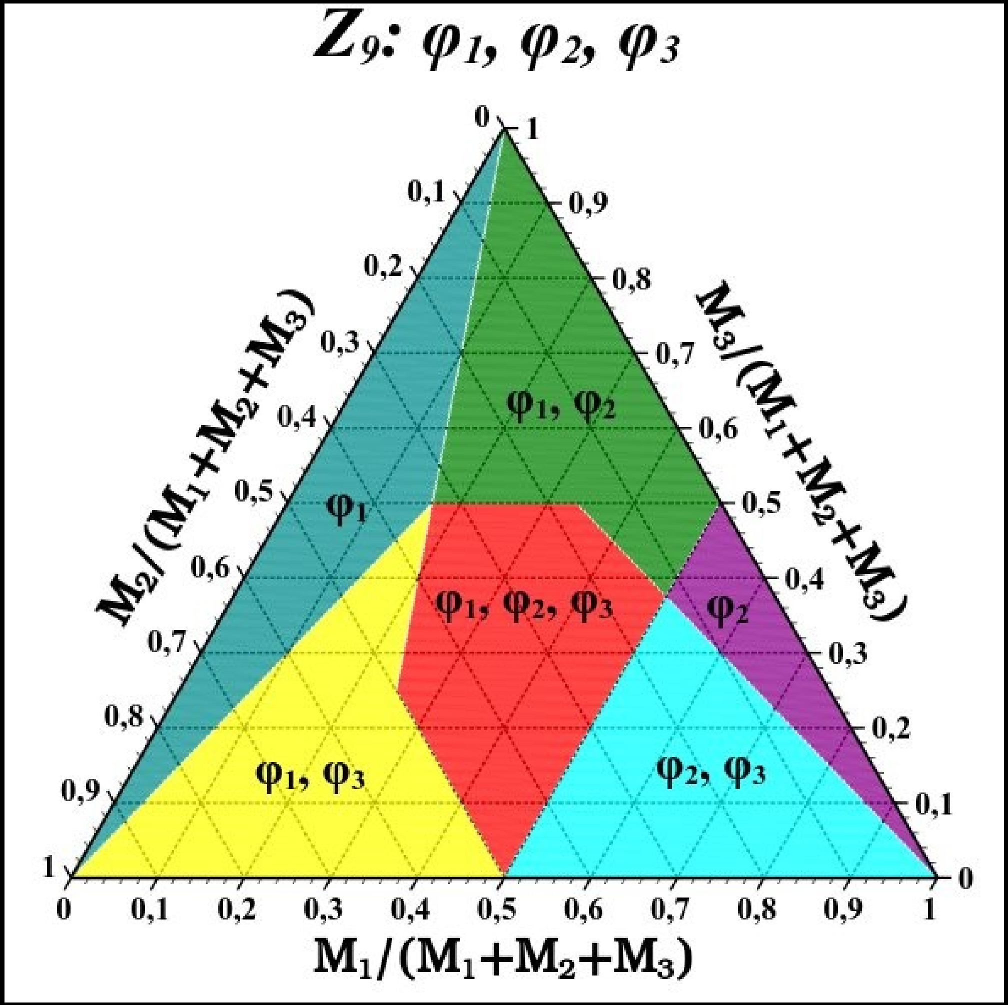

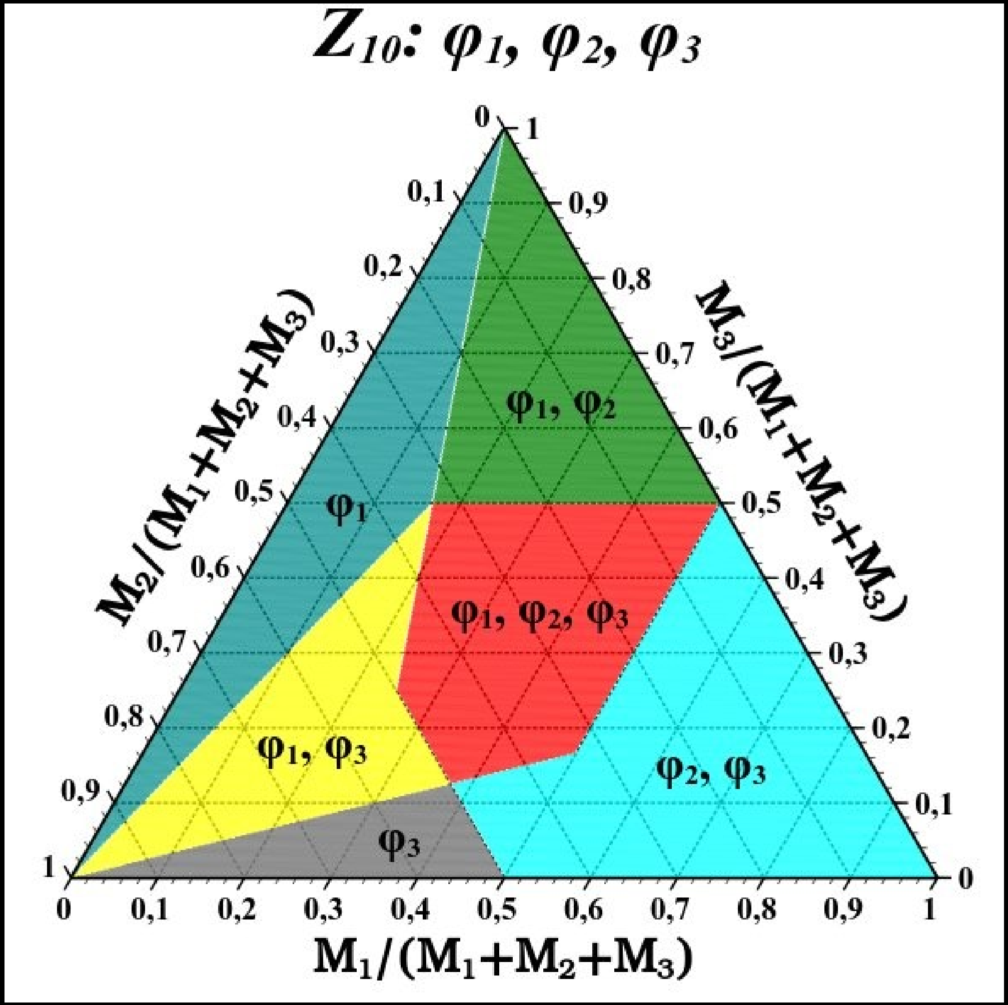

These analyses can be easily extended to more than 3 DM particles

Z_9 with fields $\varphi_{1,2,3,4}$:

It follows that the full stability region is given by the condition $M_2 < 2M_1 \wedge M_4 < 2M_2 \wedge M_4 < 2M_3 \wedge M_2 < 2M_4 \wedge M_1 < M_2 + M_3 \wedge M_2 < M_1 + M_3 \wedge M_3 < M_1 + M_2 \wedge M_1 < M_3 + M_4 \wedge M_3 < M_1 + M_4 \wedge M_4 < M_1 + M_3$

Z_{10} with fields $\varphi_{1,2,3,4,5}$:

The stability condition for the five fields is $M_2 < 2M_1$, $M_1 < M_2 + M_3$, $M_2 < M_1 + M_3$, $M_3 < M_1 + M_2$, $M_4 < 2M_2$, $M_1 < M_3 + M_4$, $M_3 < M_1 + M_4$, $M_4 < M_1 + M_3$, $M_4 < 2M_3$, $M_2 < 2M_4$, $M_2 < M_3 + M_5'$, $M_3 < M_2 + M_5'$, $M_5' < M_2 + M_3$, $M_1 < M_4 + M_5'$, $M_4 < M_1 + M_5'$, $M_5' < M_1 + M_4$.

Many models for multi-component DM can be implemented within this framework

A Z_N symmetry is well motivated

Up to N/2 DM particles can be stabilized

These models have not been studied