Dark higher-form portals

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BSM Odyssey: Turns and twists in particle theory

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Differential forms as dark matter candidates

One can define fields with more than one Lorentz indices. They are antisymmetric and fundamentally tensorial.

Number of indices

$p = 0$	$p = 1$	$p = 2$	$p = 3$
Scalar field ϕ	Vector field A^{μ}	Kalb-Ramond field $B^{\mu\nu}$	Three-form $C^{\mu\nu\rho}$

Formally, these fields are differential forms → Often encountered in string theory

Here we adopt a phenomenological vision: Can these forms be suitable DM candidates?

What do these forms propagate?

First step is to look at the number of degrees of freedom (*DOFs*) propagated by each form, taking in account for every free-theory:

The equations of motion

The gauge-symmetries

	Scalar field ϕ	Vector field A^μ	KR field $B^{\mu\nu}$	Three-form $C^{\mu\nu\rho}$
massless	1	2	1	0
massive	1	3	3	1

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Two representations of a massive spin-one particle

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Why searching higher-forms as dark-matter?

1) A different number of Lorentz indices induces different effective couplings with SM fields

2) Decomposing the forms in terms of their DOFs, we see that they propagate differently compared to vector and scalar fields

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4) Some algebraic relations, called dualities, relate higher-forms to vector and scalar fields

The duality is a path between standard and “differential” DM theories.

We expect different experimental signatures

For every form, the leading operator coupling two dark fields with fermions involves the same structure

$$\bar{\psi}_L \psi_R \phi^2$$

$$\bar{\psi}_L \psi_R A_\mu A^\mu$$

$$\bar{\psi}_L \psi_R B_{\mu\nu} B^{\mu\nu}$$

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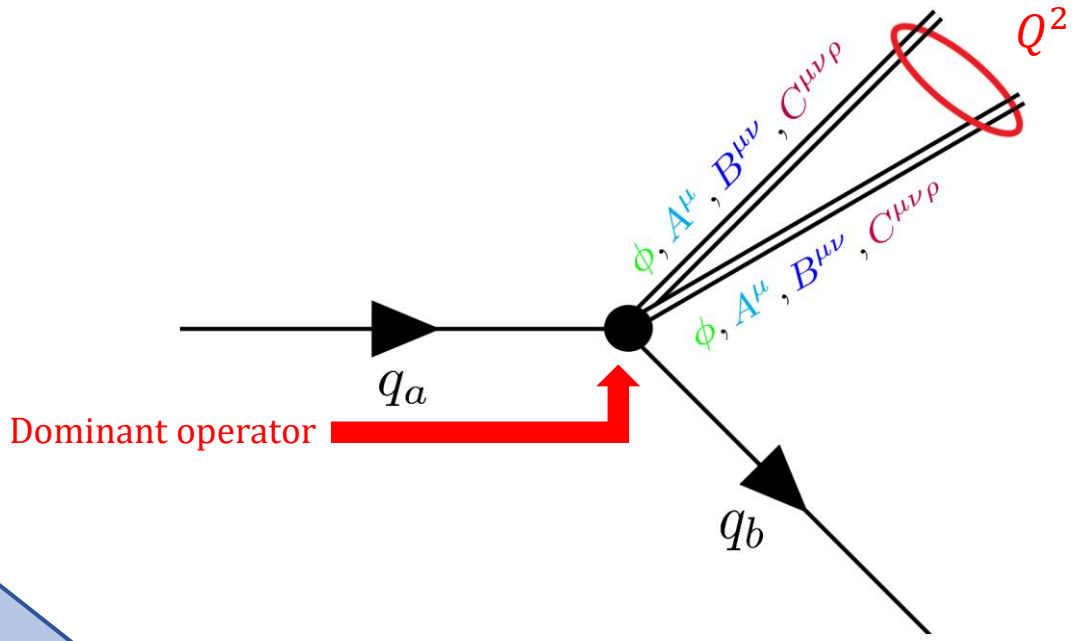

$q_a \to q_b XX$ avec $X = \phi, A^\mu, B^{\mu\nu}, C^{\mu\nu\rho}$

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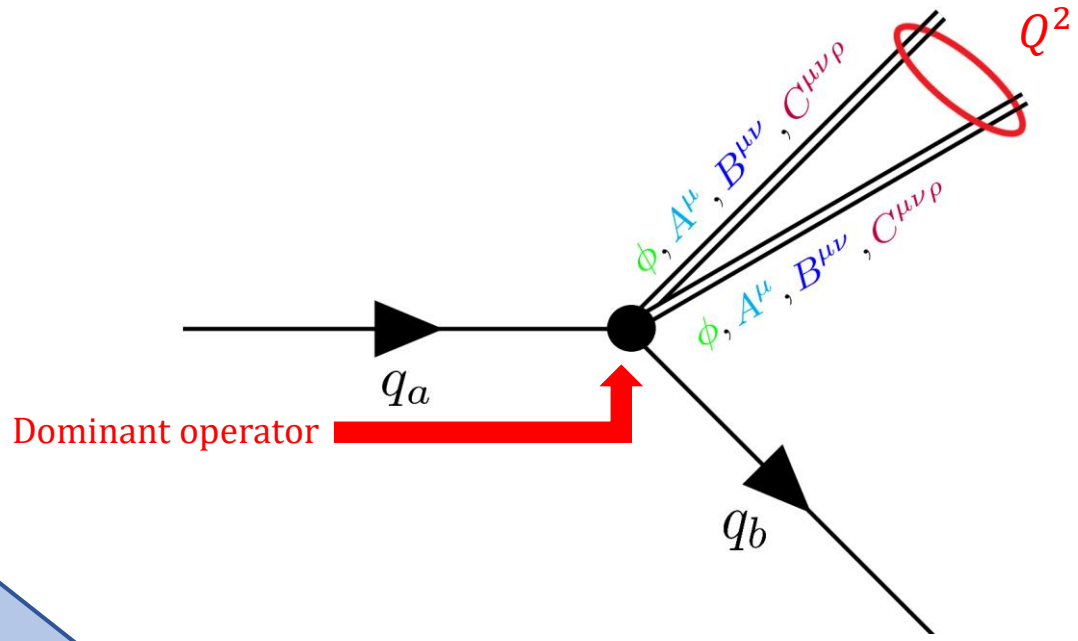
$$\bar{\psi}_L \psi_R \phi^2 \qquad \bar{\psi}_L \psi_R A_\mu A^\mu \qquad \bar{\psi}_L \psi_R B_{\mu\nu} B^{\mu\nu} \qquad \bar{\psi}_L \psi_R C_{\mu\nu\rho} C^{\mu\nu\rho}$$



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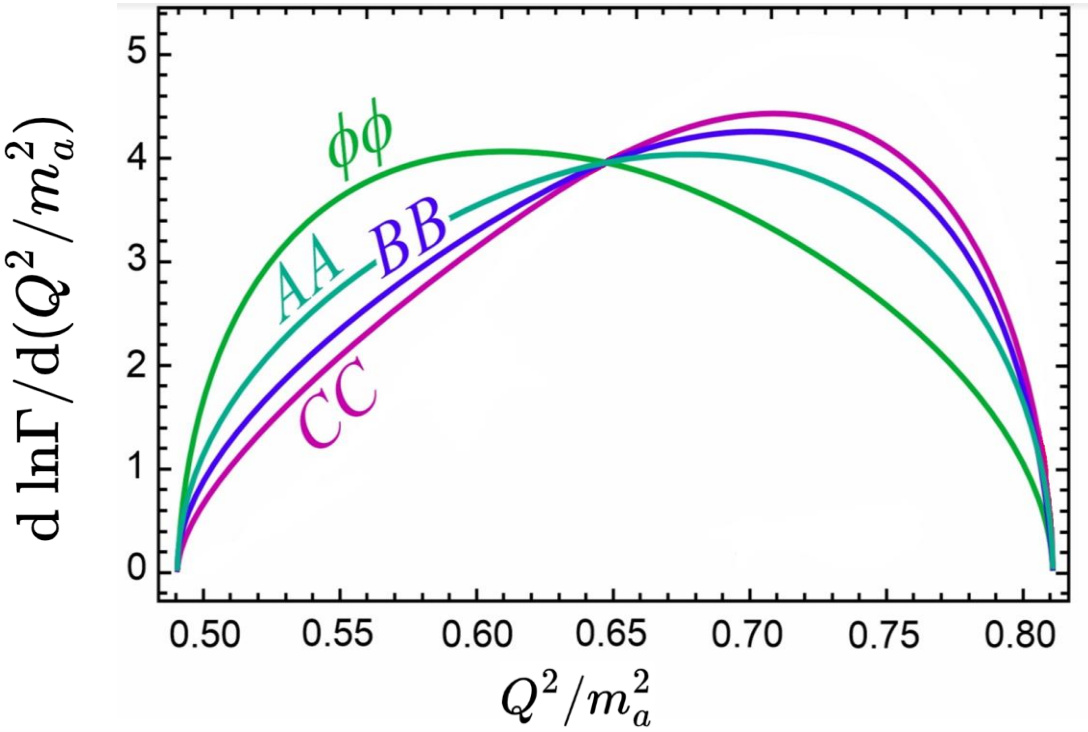

Normalized differential decay rates for $q_a \to q_b XX$, in function of the squared impulsion Q^2 normalized by m_a^2. Here, $\frac{m_b}{m_a} = 0{,}1$, $\frac{m_X}{m_a} = 0{,}35$.

This presentation was based on the results of the article:

- *Dark Higher-form portals and dualities*
- Cypris Plantier and Christopher Smith
- arXiv:2506.04795 [hep-ph]

Thank you for your attention and feel free to ask questions!