The University of Nottingham

How to calculate Feynman rules in scalar-tensor theories

and not cry in the process

Based on arXiv:2111.06357 and arXiv:2211.14300

Sergio Sevillano

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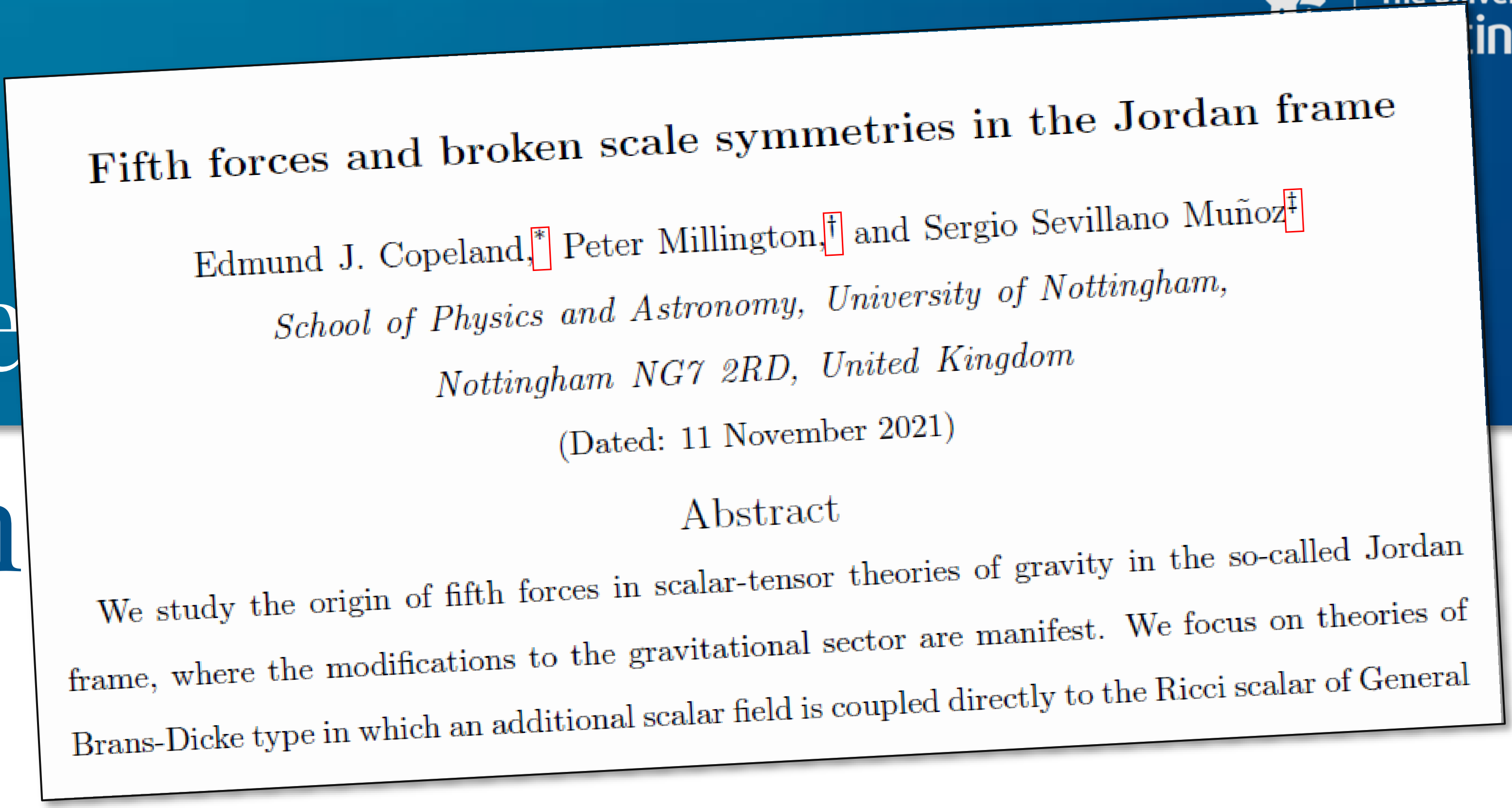

Fifth forces and broken scale symmetries in the Jordan frame

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(Dated: 11 November 2021)

Abstract

We study the origin of fifth forces in scalar-tensor theories of gravity in the so-called Jordan frame, where the modifications to the gravitational sector are manifest. We focus on theories of Brans-Dicke type in which an additional scalar field is coupled directly to the Ricci scalar of General

Based on arXiv:2111.06357 and arXiv:2211.xxxxxx

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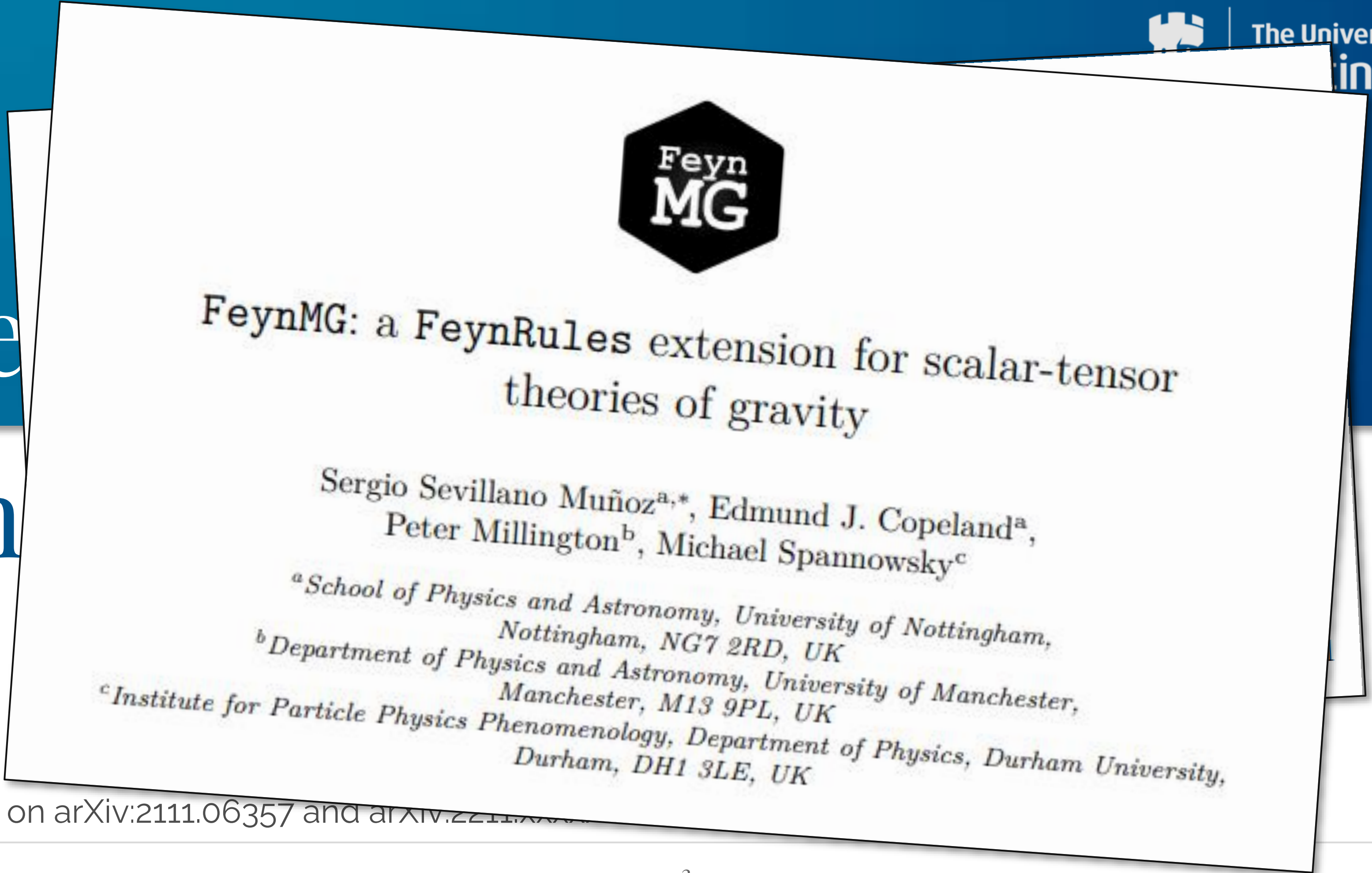
FeynMG: a FeynRules extension for scalar-tensor theories of gravity

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Based on arXiv:2111.06357 and arXiv:2211.xx

Intro to Scalar-Tensor theories

Gravitational action that has couplings between the metric and a scalar field

Lots of candidates (Horndeski, Beyond Horndeski, DHOST...)

$$\int_\Lambda d^4x\sqrt{-g}\left[aR - \frac{1}{2}g^{\mu\nu}\partial_\mu X\partial_\nu X + F(X)R + cR^2 + dR_{\mu\nu}R^{\mu\nu} + \dots\right]$$

Usually studied at cosmological/solar system scales

Intro to Scalar-Tensor theories

Every theory that introduces a new scalar degree of freedom should be also treated as a particle theory

Our plan:

1. Start with a Scalar-Tensor theory and a matter sector
2. Split pure gravitational interactions from new fifth forces using field theory
3. Get an effective theory out of scalar-tensor theories, equivalent to Beyond Standard Model

Effective theories

1. We will work with a Brans-Dicke theory and a matter sector

$$S = \int \mathrm{d}^4x \sqrt{-g}\left[\frac{1}{2}F(X)R - \frac{1}{2}Z(X)g^{\mu\nu}\partial_\mu X \partial_\nu X - U(X)\right]$$

Important:

$$F(v_X) = M_{\mathrm{pl}}^2$$

QED+Higgs toy model in flat spacetime:

$$S_m\{g_{\mu\nu}\} = \int \mathrm{d}^4x \left[-\frac{1}{4}F^{\mu\nu}F_{\mu\nu} + \frac{1}{2}\partial_\mu\phi\partial^\mu\phi + i\bar{\psi}\gamma^\mu\nabla_\mu\psi - y\bar{\psi}\phi\psi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda}\right]$$

Effective theories

$$S_m\{g_{\mu\nu}\} = \int \mathrm{d}^4x \left[-\frac{1}{4}F^{\mu\nu}F_{\mu\nu} + \frac{1}{2}\partial_\mu\phi\partial^\mu\phi + i\bar{\psi}\gamma^\mu\nabla_\mu\psi - y\bar{\psi}\phi\psi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda} \right]$$

Add explicit sources of gravity

$$S_m\{g_{\mu\nu}\} = \int \mathrm{d}^4x\sqrt{-g} \left[-\frac{1}{4}g^{\alpha\mu}g^{\beta\nu}F_{\alpha\beta}F_{\mu\nu} + \frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi + i\bar{\psi}e^\mu_a\gamma^a\nabla_\mu\psi - y\bar{\psi}\phi\psi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda} \right]$$

Effective theories

$$S_m\{g_{\mu\nu}\} = \int \mathrm{d}^4x\sqrt{-g}\left[-\frac{1}{4}g^{\alpha\mu}g^{\beta\nu}F_{\alpha\beta}F_{\mu\nu} + \frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi + i\bar{\psi}e_a^\mu\gamma^a\nabla_\mu\psi - y\bar{\psi}\phi\psi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda}\right]$$

Derivatives → Covariant derivatives

$$\nabla_\mu Y_\nu = \partial_\mu Y_\nu + \Gamma^\rho_{\mu\nu}Y_\rho$$

$$\nabla_\mu\psi = \partial_\mu\psi - qA_\mu\psi - \frac{1}{2}\Omega_\mu\psi$$

Effective theories

Our theory:

$$
\begin{aligned}
S = \int \mathrm{d}^4 x \sqrt{-g} \Big[& -\frac{F(X)}{2} R + \frac{Z(X)}{2} g^{\mu\nu} \partial_\mu X \partial_\nu X - U(X) \\
& - \frac{1}{4} g^{\alpha\mu} g^{\beta\nu} F_{\alpha\beta} F_{\mu\nu} + \frac{1}{2} g^{\mu\nu} \partial_\mu \phi \partial_\nu \phi \\
& + i \bar{\psi} e^\mu_a \gamma^a \partial_\mu \psi - \frac{1}{2} \bar{\psi} e^\mu_a \gamma^a \Omega_\mu \psi - q \bar{\psi} e^\mu_a \gamma^a A_\mu \psi \\
& - y \bar{\psi} \phi \psi - \frac{1}{2} \mu^2 \phi^2 + \frac{\lambda}{4!} \phi^4 - \frac{3\mu^4}{2\lambda} \Big] .
\end{aligned}
$$

Effective theories

2. Split pure gravitational interactions from new fifth forces using field theory

$$S = \int \mathrm{d}^4x \sqrt{-g} \left[\frac{1}{2} F(X) R - \frac{1}{2} Z(X) g^{\mu\nu} \partial_\mu X \partial_\nu X - U(X) \right]$$

Go to the Einstein frame

?

(Only for Brans-Dicke like)

Stay in the Jordan frame

?

Effective theories

Einstein Frame:

Perform a Weyl transformation such that gravity eats the coupling to the scalar

$$g_{\mu\nu} \to \frac{\tilde{M}_{\rm pl}^2}{F(X)} \tilde{g}_{\mu\nu} \qquad g^{\mu\nu} \to \frac{F(X)}{\tilde{M}_{\rm pl}^2} \tilde{g}^{\mu\nu}$$

$$\sqrt{-g}\frac{F(X)}{2}R \to \sqrt{-\tilde{g}}\left(\frac{\tilde{M}_{\rm pl}^2}{2}\tilde{R} - \frac{3\tilde{M}_{\rm pl}^2 F'(X)^2}{4F(X)^2}\tilde{g}^{\mu\nu}\partial_\mu X \partial_\nu X\right)$$

$$e_a^\mu \gamma^a \Omega_\mu \to \frac{\sqrt{X}}{\tilde{M}_{\rm pl}} \tilde{e}_a^\mu \gamma^a \left(\tilde{\Omega}_\mu + \frac{3i}{2}\frac{F'(X)}{F(X)}\partial_\mu X\right),$$

Effective theories

Einstein Frame:

Perform a Weyl transformation such that gravity eats the coupling to the scalar

$$S = \int \mathrm{d}^4x\sqrt{-\tilde{g}}\left[-\frac{\tilde{M}_{\rm pl}^2}{2}R + \frac{\tilde{M}_{\rm pl}^2}{2}\left[\frac{Z(X)}{F(X)} + \frac{3F'(X)^2)}{2F(X)^2}\right]\tilde{g}^{\mu\nu}\partial_\mu X\partial_\nu X - \frac{\tilde{M}_{\rm pl}^4}{F(X)^2}U(X)\right.$$
$$-\frac{1}{4}\tilde{g}^{\alpha\mu}\tilde{g}^{\beta\nu}F_{\alpha\beta}F_{\mu\nu} + \frac{\tilde{M}_{\rm pl}^2}{2F(X)}\tilde{g}^{\mu\nu}\partial_\mu\phi\partial_\nu\phi - q\frac{\tilde{M}_{\rm pl}^3}{F(X)^{3/2}}\bar{\psi}\tilde{e}_a^\mu\gamma^a A_\mu\psi$$
$$+i\frac{\tilde{M}_{\rm pl}^3}{F(X)^{3/2}}\bar{\psi}\tilde{e}_a^\mu\gamma^a\partial_\mu\psi - \frac{1}{2}\frac{\tilde{M}_{\rm pl}^3}{F(X)^{3/2}}\bar{\psi}\tilde{e}_a^\mu\gamma^a\psi\left(\tilde{\Omega}_\mu + \frac{3i}{2}\frac{F'(X)}{F(X)}\partial_\mu X\right)$$
$$\left.-\frac{\tilde{M}_{\rm pl}^4}{F(X)^2}\left(y\bar{\psi}\phi\psi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda}\right)\right],$$

Effective theories

Einstein Frame:

Canonically normalise the theory through

$$\tilde{X}(X) \equiv \tilde{M}_{\rm pl} \int_{X_0}^{X} {\rm d}\hat{X} \sqrt{\frac{Z(\hat{X})}{F(\hat{X})} + \frac{3F'(\hat{X})^2}{2F(\hat{X})^2}}\,.$$

$$\psi \to \sqrt{\frac{\tilde{F}(\tilde{X})^{3/2}}{\tilde{M}_{\rm pl}^3}}\tilde{\psi} \qquad\qquad \phi \to \frac{\sqrt{\tilde{F}(\tilde{X})}}{\tilde{M}_{\rm pl}}\tilde{\phi}$$

Effective theories

Einstein Frame:

Lost simplicity of our theory

Mass and kinetic mixings from Higgs producing the fifth forces

Infinite many couplings appearing out of 'nowhere'

We can ignore gravity and just do QFT

$$\mathcal{L} = -\frac{\tilde{M}_{\rm pl}^2}{2}R + \frac{1}{2}\tilde{g}^{\mu\nu}\partial_\mu\tilde{X}\partial_\nu\tilde{X} - \frac{1}{4}\tilde{g}^{\alpha\mu}\tilde{g}^{\beta\nu}F_{\alpha\beta}F_{\mu\nu}$$
$$+ i\bar{\tilde{\psi}}\tilde{e}^\mu_a\gamma^a\partial_\mu\tilde{\psi} - \frac{1}{2}\bar{\tilde{\psi}}\tilde{e}^\mu_a\gamma^a\tilde{\Omega}_\mu\tilde{\psi} - q\bar{\tilde{\psi}}\tilde{e}^\mu_a\gamma^a A_\mu\tilde{\psi}$$
$$+ \frac{1}{2}\tilde{g}^{\mu\nu}\partial_\mu\tilde{\phi}\partial_\nu\tilde{\phi} + \underline{\frac{1}{2}\frac{\tilde{F}'(\tilde{X})}{\tilde{F}(\tilde{X})}\tilde{\phi}\tilde{g}^{\mu\nu}\partial_\mu\tilde{\phi}\partial_\nu\tilde{X}}$$
$$+ \frac{1}{8}\left(\frac{\tilde{F}'(\tilde{X})}{\tilde{F}(\tilde{X})}\right)^2\tilde{\phi}^2\tilde{g}^{\mu\nu}\partial_\mu\tilde{X}\partial_\nu\tilde{X} - y\bar{\tilde{\psi}}\tilde{\phi}\tilde{\psi}$$
$$+ \underline{\frac{\tilde{M}_{\rm pl}^2}{\tilde{F}(\tilde{X})}\frac{1}{2}\mu^2\tilde{\phi}^2} - \frac{\lambda}{4!}\tilde{\phi}^4 + \frac{3\mu^4}{2\lambda}\frac{\tilde{M}_{\rm pl}^4}{\tilde{F}(\tilde{X})^2} - \frac{\tilde{M}_{\rm pl}^4}{\tilde{F}(\tilde{X})^2}\tilde{U}(\tilde{X})$$

Effective theories

Jordan Frame: Stay where we are, and deal with it.

Usefulness: Some theories do not have an Einstein frame.

Gravity itself will be the source of fifth forces, therefore…

$$\begin{aligned} g_{\mu\nu} &= \eta_{\mu\nu} + h_{\mu\nu} + \cdots \\ g^{\mu\nu} &= \eta^{\mu\nu} - h^{\mu\nu}, \end{aligned}$$

Effective theories

Jordan Frame:

Recall the action:

$$S = \int \mathrm{d}^4x\sqrt{-g}\Big[-\frac{F(X)}{2}R + \frac{Z(X)}{2}g^{\mu\nu}\partial_\mu X\partial_\nu X - U(X)$$
$$- \frac{1}{4}g^{\alpha\mu}g^{\beta\nu}F_{\alpha\beta}F_{\mu\nu} + \frac{1}{2}g^{\mu\nu}\partial_\mu\phi\partial_\nu\phi$$
$$+ i\bar{\psi}e^\mu_a\gamma^a\partial_\mu\psi - \frac{1}{2}\bar{\psi}e^\mu_a\gamma^a\Omega_\mu\psi - q\bar{\psi}e^\mu_a\gamma^a A_\mu\psi$$
$$- y\bar{\psi}\phi\psi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda}\Big].$$

Effective theories

Jordan Frame:

Linearizing gravity is tedious, and I won't make you go through to this.

Result:

$$\mathcal{L} = \frac{F(X)}{4}\left(\frac{1}{4}\partial_\mu h \partial^\mu h - \frac{1}{2}\partial_\rho h_{\mu\nu}\partial^\rho h^{\mu\nu}\right) + \frac{F'(X)}{4}\partial_\mu X \partial^\mu h$$
$$-\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \left[\frac{Z(X)}{2} + \frac{F'(X)^2}{4F(X)}\right]\partial_\mu X \partial^\mu X + \frac{1}{2}\partial_\mu \phi \partial^\mu \phi$$
$$+i\bar{\psi}\gamma^\mu \partial_\mu \psi - \frac{1}{2}\bar{\psi}\gamma^\mu \Omega_\mu \psi - q\bar{\psi}\gamma^\mu A_\mu \psi$$
$$-y\bar{\psi}\phi\psi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda} - U(X) + \frac{1}{2}h_{\mu\nu}T^{\mu\nu}\Big] + \cdots$$

Effective theories

Jordan Frame:

$$\chi(X) = \int_{X_0}^{X} \mathrm{d}\hat{X} \sqrt{Z(\hat{X}) + \frac{F'(\hat{X})^2}{2F(\hat{X})}}.$$

$$\begin{aligned}\mathcal{L} = & \frac{\hat{F}(\chi)}{4}\left(\frac{1}{4}\partial_\mu h \partial^\mu h - \frac{1}{2}\partial_\rho h_{\mu\nu}\partial^\rho h^{\mu\nu}\right) + \frac{\hat{F}'(\chi)}{4}\partial_\mu \chi \partial^\mu h \\ & -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \frac{1}{2}\partial_\mu\chi\partial^\mu\chi + \frac{1}{2}\partial_\mu\phi\partial^\mu\phi \\ & +i\bar{\psi}\gamma^\mu\partial_\mu\psi - \frac{1}{2}\bar{\psi}\gamma^\mu\Omega_\mu\psi - q\bar{\psi}\gamma^\mu A_\mu\psi \\ & -y\bar{\psi}\phi\psi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda} - \hat{U}(\chi) + \frac{1}{2}h_{\mu\nu}T^{\mu\nu}\Bigg] + \cdots ,\end{aligned}$$

Effective theories

Jordan Frame:

$$\mathcal{L} = \frac{\hat{F}(\chi)}{4}\left(\frac{1}{4}\partial_\mu h \partial^\mu h - \frac{1}{2}\partial_\rho h_{\mu\nu}\partial^\rho h^{\mu\nu}\right) + \frac{\hat{F}'(\chi)}{4}\partial_\mu \chi \partial^\mu h$$

1. Expand around vevs

$$\hat{F}(\chi) \to \hat{F}(\chi)|_{\chi=v_\chi} + \chi \hat{F}'(\chi)|_{\chi=v_\chi} + \frac{\chi^2}{2!}\hat{F}''(\chi)|_{\chi=v_\chi} + \dots$$

2. Diagonalize the kinetic matrix

$$h_{\mu\nu} \to \frac{2}{M_{\rm pl}} h_{\mu\nu} + \frac{2}{M_{\rm pl}} \frac{\hat{F}'(v_\chi)}{\sqrt{M_{\rm pl}^2 + \hat{F}'(v_\chi)^2}} \sigma \eta_{\mu\nu}$$

$$\chi \to -\frac{1}{\sqrt{1 + \hat{F}'(v_\chi)^2/M_{\rm pl}^2}}\sigma,$$

Effective theories

Jordan Frame:

$$\begin{aligned}\mathcal{L} =& \frac{1}{4}\partial_\mu h \partial^\mu h - \frac{1}{2}\partial_\rho h_{\mu\nu}\partial^\rho h^{\mu\nu} - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} \\ &+ i\bar{\psi}\gamma^\mu\partial_\mu\psi - \frac{1}{2}\bar{\psi}\gamma^\mu\Omega_\mu\psi - q\bar{\psi}\gamma^\mu A_\mu\psi - y\bar{\psi}\phi\psi \\ &+ \frac{1}{2}\partial_\mu\sigma\partial^\mu\sigma + \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - \frac{1}{2}\mu^2\phi^2 + \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda} \\ &+ \frac{1}{M_{\rm pl}}h_{\mu\nu}T^{\mu\nu} + \frac{1}{M_{\rm pl}}\frac{\hat{F}'(v_\chi)}{\sqrt{M_{\rm pl}^2 + \hat{F}'(v_\chi)^2}}\sigma T^\mu_\mu + \cdots\end{aligned}$$

Fifth forces!

T^μ_μ=0 for scale invariant terms

Effective theories

Both frames give the same observables (as expected)

Fifth forces couple to every scale dependent part of the theory

The results are very model dependent!!!

Go to the Einstein frame

Conformal Transformation
Canonical normalization
Expansion around non-trivial vevs
Kinetic mixings
Mass mixings

Stay in the Jordan frame

Expansion of gravity
Canonical normalization
Expansion around non-trivial vevs
Kinetic mixings to graviton

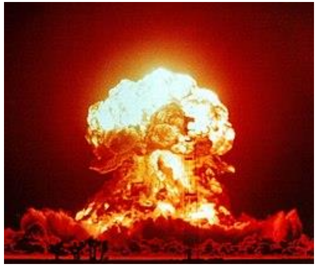
Effective theories

Both frames give the same observables (as expected)

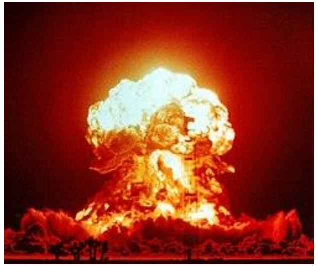
Fifth forces couple to every scale dependent part of the theory

The results are very model dependent!!!

Go to the Einstein frame



Stay in the Jordan frame



Can we get a computer to do it?

How do particle phenomenologists test modifications to the SM?

Use FeynRules:

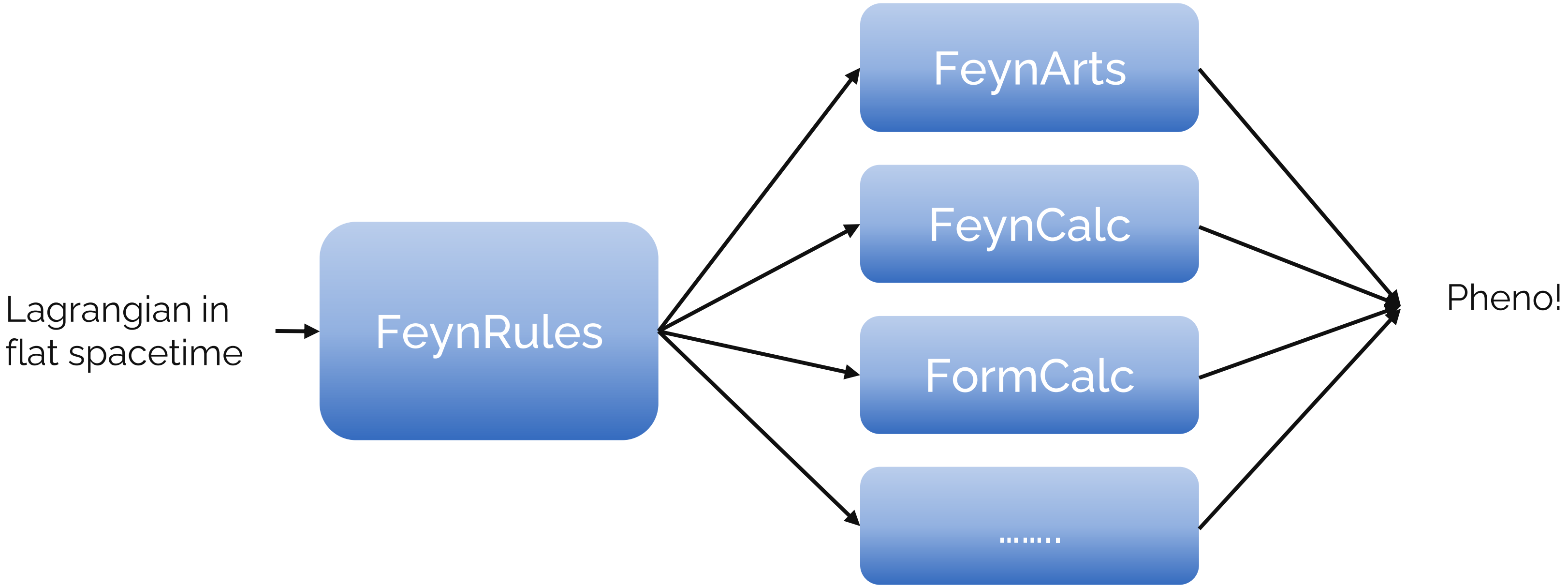
-Input a ModelFile with a flat spacetime Lagrangian

-Mathematica Package that generates its Feynman rules

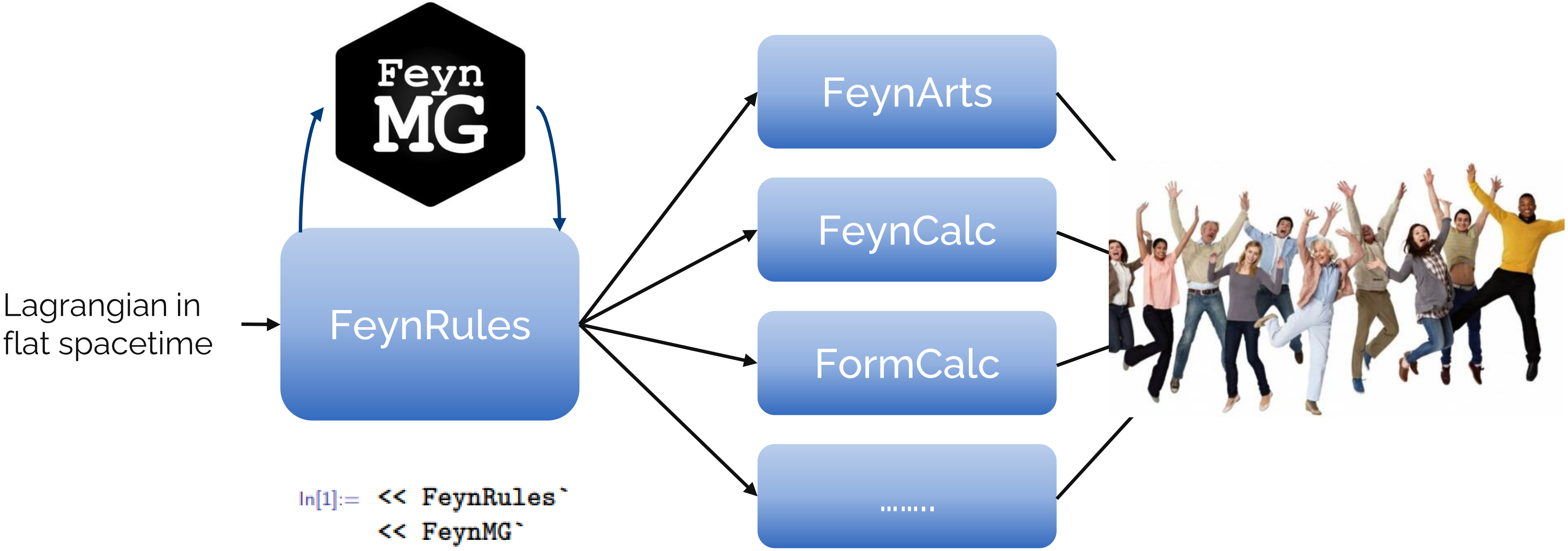
-Use compatible packages to perform advanced analysis

-Compare results with data from colliders, such as LHC, Fermilab etc…

FeynRules


Lagrangian in
flat spacetime
FeynRules
FeynArts
FeynCalc
FormCalc
………
Pheno!

FeynMG!




```
In[1]:= << FeynRules`
        << FeynMG`
```

What can FeynMG do?

-Take any Lagrangian defined in flat space-time (same Model Files as for FeynRules) and insert all the gravitational couplings

$$\mathtt{LQED} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + \frac{1}{2}\partial_\mu\phi\partial^\mu\phi - \alpha\partial^\mu A_\mu\partial^\nu A_\nu + i\bar{\psi}\gamma^\mu\partial_\mu\psi - q\bar{\psi}\gamma^\mu A_\mu\psi - y\bar{\psi}\phi\psi + \frac{1}{2}\mu^2\phi^2 - \frac{\lambda}{4!}\phi^4 - \frac{3\mu^4}{2\lambda}.$$

```
LCurv=InsertCurv[LQED]
```

$$-\frac{3\,\mu^4}{2\,\mathrm{lam}} + \frac{\mu^2\,\mathrm{phi}^2}{2} - \frac{\mathrm{lam}\ \mathrm{phi}^4}{24} - \mathrm{phi}\,\bar{\mathrm{psi}}_{\mathrm{i1,i2}}\mathrm{psi}_{\mathrm{i1,i2}} + \frac{1}{2}\partial_{\mathrm{a2}}[\mathrm{phi}]\,\partial_{\mathrm{mu}}[\mathrm{phi}]\,\mathrm{gUp}[\mathrm{a2,mu}] - \frac{1}{4}\mathrm{D^{Grav}}_{\mathrm{nu}}[\mathrm{A_{a3}}]\,\mathrm{D^{Grav}}_{\mathrm{a4}}[\mathrm{A_{mu}}]\,\mathrm{gUp}[\mathrm{a3,mu}]\,\mathrm{gUp}[\mathrm{a4,nu}] + \overset{[7\to9]}{\cdots\cdots} - \mathrm{e}\,\mathrm{A_{mu}}\,\bar{\mathrm{psi}}_{\mathrm{i1,i2}}\cdot\mathrm{psi}_{\mathrm{j1,i2}}\gamma_{\mathrm{i1,j1}}{}^{\mathrm{v1}}\,\mathrm{VUp}[\mathrm{mu,v1}] + \mathrm{i}\,\bar{\mathrm{psi}}_{\mathrm{i1,i2}}\cdot\partial_{\mathrm{mu}}[\mathrm{psi}_{\mathrm{j1,i2}}]\,\gamma_{\mathrm{i1,j1}}{}^{\mathrm{v2}}\,\mathrm{VUp}[\mathrm{mu,v2}] + \frac{1}{8}\mathrm{i}\,\partial_{\mathrm{mu}}[\mathrm{VUp}[\mathrm{d1,c1}]]\,\bar{\mathrm{psi}}_{\mathrm{i1,i2}}\cdot\mathrm{psi}_{\mathrm{j1,i2}}\,\mathrm{VDown}[\mathrm{c2,c1}]\,\mathrm{VUp}[\mathrm{mu,v3}]\,\gamma^{\mathrm{c2}}\cdot\gamma^{\mathrm{d1}}\cdot\gamma^{\mathrm{v3}}{}_{\mathrm{i1,j1}} + \overset{[13\to19]}{\cdots\cdots}{}_{[19]}$$

What can FeynMG do?

-Allows the user to insert new scalar degrees of freedom and any gravitational theory

```
In[4]:= LJordan= LCurv + chi RScalar/2 + (w/(2chi))
        gUp[Index[Lorentz,mu],Index[Lorentz,nu]]
        del[chi,Index[Lorentz,mu]] del[chi,Index[Lorentz,nu]]
        + (muC^2chi)/2 - (lamC(chi^2))/(4!)
        - (3muC^4)/(2lamC);
```

What can FeynMG do?

-Perform all the necessary operations to calculate the Effective Theory

Go to the Einstein frame

- Conformal Transformation — `ToEinsteinFrame`
- Canonical normalization — `CanonScalar`
- Expansion around non-trivial vevs — `VevExpand`
- Kinetic mixings — `KineticDiagMG`
- Mass mixings — `MassDiagMG`

Stay in the Jordan frame

- Expansion of gravity — `LinearizeGravity`
- Canonical normalization
- Expansion around non-trivial vevs
- Kinetic mixings to graviton — `GravKinMixing`

And much more! See appendix C in arXiv:2211.14300

What can FeynMG do?

-Output a Model File that can be directly used in FeynRules and all compatible packages

```
In[18]:= OutputModelMG[OldModelFile,NewModelFile,Lagrangian]
```

What can FeynMG do?

-Take any Lagrangian defined in flat space-time (same Model Files as for FeynRules) and insert all the gravitational couplings

-Allows the user to insert new scalar degrees of freedom and any gravitational theory

-Perform all the necessary operations to calculate the Effective Theory

-Output a Model File that can be directly used in FeynRules and all compatible packages

Test Scalar-Tensor theories in the lab!

Based on arXiv:2111.06357 and arXiv:2211.14300

Thank you for listening

Feyn MG

Any questions?

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https://gitlab.com/feynmg/FeynMG

SCAN ME