

# Automatic Lagrangian Generation

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# Outline

- 1 Introduction
- 2 Status
- 3 Summary

# What A Model Builder Wants

	$SU(3)^c$	$SU(2)_L$	$U(1)_Y$	$U(1)_B$	$U(1)_L$	(Lorentz)
$Q_L$	3	2	$+\frac{1}{3}$	$+\frac{1}{3}$	0	$(\frac{1}{2}, 0)$
$u_R$	3	1	$+\frac{4}{3}$	$+\frac{1}{3}$	0	$(0, \frac{1}{2})$
$d_R$	3	1	$-\frac{2}{3}$	$+\frac{1}{3}$	0	$(0, \frac{1}{2})$
$\ell_L$	1	2	-1	0	1	$(\frac{1}{2}, 0)$
$e_R$	1	1	+2	0	1	$(0, \frac{1}{2})$
$\nu_R$	1	1	0	0	1	$(0, \frac{1}{2})$
$\Phi$	1	2	+1	0	0	$(0, 0)$

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# What A Model Builder Wants

$$\begin{aligned}\mathcal{L} = \mathcal{L}_{\text{KE}} \\ + \left( y_u \bar{Q}_L \Phi^* u_R + y_d \bar{Q}_L \Phi d_R + y_L \bar{\ell}_L \Phi e_R + y_\nu \bar{\ell}_L \Phi^* \nu_R + \text{h.c.} \right) \\ + m^2 |\Phi|^2 - \frac{1}{2} \lambda |\Phi|^4\end{aligned}$$

- Some couplings determined by experiment
- Scan over the rest

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# Introducing *galileo*

## galileo

→ computer code for automated Lagrangian Generation

- Written in C++
- Core
  - Workhorse: handles all computations
  - Written as a library
- GUI
  - Interactive portion
  - Written as a web application (browser based)

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# Introducing *galileo*

## Goals (for First Release)

- Symmetries
  - Compact Lie Groups
  - $U(1)$
  - Discrete Symmetry  $\mathbb{Z}_n$
- Fields
  - Scalars
  - Fermions
  - Vectors
  - Super
- Functionality
  - Automatic Lagrangian Generation
  - Read and Save Model
  - Output to FeynRules

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## Goals (for First Release)

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- Compact Lie Groups
- $U(1)$
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} Dialog to enter and edit  
Symbol in Main Window

- Fields

- Scalars
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} Dialog to enter and edit  
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- Functionality

- Automatic Lagrangian Generation
- Read and Save Model
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◀ Display in Main Window  
} Menu option

# Outline

- 1 Introduction
- 2 Status**
- 3 Summary



# Status: Core

- Understands  $A_n, B_n, C_n, D_n, G_2, F_4, E_6, E_7, E_8, U(1), \mathbb{Z}_n$ 
  - Arbitrary Representations
  - All Generators of any Representations
  - Gives Singlets of Product States
- Understands Spin 0,  $\frac{1}{2}$ , and 1 fields (fundamental objects)
- Understands Superfields
- Generates Lagrangian
  - completely and automatically generated given fields
  - Handles all operators up to dimension 6
  - For SUSY Generates Kahler potential and Superpotential
- Still Needs to Read/Write

# Status: Interface

- Working, but not finished or tested
- Uses wt (c++ library for web applications)
  - Run on local machine
  - Run on remote server
- Interacts with core code..
- Better to just show

# Interface

The screenshot shows a web browser window titled "SandBox App" with the address bar displaying "0.0.0.0:1234". The browser's address bar includes navigation icons and a search bar with the text "Google". Below the address bar, there are three buttons labeled "G", "F", and "Config". The main content area is divided into three sections:

- Symmetry Groups**: A section with a large empty rectangular box below the header.
- Fields**: A section containing three lines of text:
  - $S = \{\}$
  - $F = \{\}$
  - $V = \{\}$
- Lagrangian**: A section with a large empty rectangular box below the header.

The browser's status bar at the bottom shows a red error icon and a magnifying glass icon.

# Interface

The screenshot shows a web browser window titled "SandBox App" with the address bar displaying "0.0.0.0:1234". The browser's address bar includes a search icon and a home icon. The application interface has a top navigation bar with buttons for "G", "F", and "Config". The main content area is divided into three sections: "Symmetry Groups", "Fields", and "Lagrangian".

The "Fields" section contains the following text:

```
S = {}  
F = {}  
V = {}
```

The "Lagrangian" section is currently empty. A "Configurations" dialog box is open over the "Lagrangian" section, containing the following settings:

```
Mass D = 5  
SUSY N = 0
```

The dialog box has "Cancel" and "Ok" buttons at the bottom.

# Interface

SandBox App

0.0.0.0:1234

Google

G F Config

Symmetry Groups

Fields

S = {}

F = {}

V = {}

Lagrangian

## Interface

The screenshot displays a web application interface for managing Symmetry Groups. The main window has a title bar 'SandBox App' and a browser address bar showing '0.0.0.0:1234'. The interface includes a navigation menu with 'G', 'F', and 'Config' buttons. The main content area is divided into sections: 'Symmetry Groups', 'Fields', and 'Lagrangian'. Under 'Fields', there are three entries:  $S = \{\}$ ,  $F = \{\}$ , and  $V = \{\}$ . A modal dialog titled 'Symmetry Group' is open, showing a 'Main' tab and a 'Boson' tab. The 'Main' tab contains the following fields:

- Group Name:
- Group Label:
- Type:
- Group:

Buttons for 'Cancel' and 'Ok' are located at the bottom of the dialog.

## Interface

The screenshot shows a web browser window titled "SandBox App" with the address "0.0.0.0:1234". The browser's search bar contains "Google". The application interface has a top navigation bar with "G", "F", and "Config" buttons. The main content area is divided into three sections: "Symmetry Groups", "Fields", and "Lagrangian".

The "Fields" section contains the following definitions:

- S = {}
- F = {}
- V = {}

The "Symmetry Group" dialog box is currently open, displaying the "Boson" tab. It includes the following fields:

- Gauge Boson:** A section header.
- Symbol:**
- Subscript:**
- Boson Name:**
- Coupling Name:**

At the bottom of the dialog are "Cancel" and "Ok" buttons.

# Interface

SandBox App

0.0.0.0:1234

Google

G F Config

Symmetry Groups

U(1)

Fields

S = {}

F = {}

V = {Y}

Lagrangian

$$-\frac{1}{4} Y_{\mu\nu} Y^{\mu\nu}$$



## Interface

The screenshot shows a web browser window titled "SandBox App" with the address "0.0.0.0:1234". The browser's address bar includes a search icon and the text "Google". The application interface has a top navigation bar with "G", "F", and "Config" buttons. The main content area is divided into sections: "Symmetry Groups" (U(1)), "Fields" (S = {}, F = {}, V = {Y}), and "Lagrangian" ( $-\frac{1}{4} \gamma_{\mu\nu} \gamma^{\mu\nu}$ ). A "Field" dialog box is open in the center, with "Main" and "Reps" tabs. The "Main" tab is active, showing fields for "Symbol" (e), "Subscript" (L), "ASCII Name" (eL), "Spin" (1/2: Fermion), and "Chirality" (left). "Cancel" and "Ok" buttons are at the bottom of the dialog.

## Interface

The screenshot shows a web browser window titled "SandBox App" with the address "0.0.0.0:1234". The application interface is divided into several sections:

- Symmetry Groups:** U(1)
- Fields:**
  - S = {}
  - F = {}
  - V = {Y}
- Lagrangian:**  $-\frac{1}{4} Y_{\mu\nu} Y^{\mu\nu}$

A "Field" dialog box is open, showing the "Reps" tab. It contains a table for defining representations:

Reps		
U(1):	-1	✓
	1	/
	1	

The dialog also includes "Cancel" and "Ok" buttons.

# Interface

The screenshot shows a web browser window titled "SandBox App" with the address bar displaying "0.0.0.0:1234". The browser's address bar includes a search icon and a home icon. Below the address bar, there are navigation buttons: "G", "F", and "Config". The main content area is divided into three sections:

- Symmetry Groups**: U(1)
- Fields**:
  - S = {}
  - F = {e<sub>L</sub>}
  - V = {γ}
- Lagrangian**:
 
$$-\frac{1}{4} \gamma_{\mu\nu} \gamma^{\mu\nu} + i \bar{e}_L \gamma_\mu D^\mu e_L$$

At the bottom of the browser window, there are standard navigation icons (back, forward, search, etc.).

## Interface

SandBox App

0.0.0.0:1234

Google

Config

Symmetry Groups

U(1)

Fields

S = {}

F = {e<sub>L</sub>}

V = {ψ}

Lagrangian

$$-\frac{1}{4} \gamma_{\mu\nu} \gamma^{\mu\nu} + i \bar{e}_L \gamma_\mu D^\mu e_L$$

**Field**

Main Reps

Main

Symbol

Subscript

ASCII Name

Spin

Chirality

Cancel Ok

## Interface

SandBox App

0.0.0.0:1234

Google

Config

Symmetry Groups

U(1)

Fields

S = {}

F = {e<sub>L</sub>}

V = {γ}

Lagrangian

$$-\frac{1}{4} \gamma_{\mu\nu} \gamma^{\mu\nu} + i \bar{e}_L \gamma_\mu D^\mu e_L$$

Field

Main Reps

Representations

U(1):	-1	✓	1	/	1
-------	----	---	---	---	---

Cancel Ok

## Interface

SandBox App

0.0.0.0:1234

Google

G F Config

Symmetry Groups

U(1)

Fields

S = {}

F = {e<sub>L</sub>, e<sub>R</sub>}

V = {γ}

Lagrangian

$$-\frac{1}{4} \gamma_{\mu\nu} \gamma^{\mu\nu} + i \bar{e}_L \gamma_\mu D^\mu e_L + i \bar{e}_R \gamma_\mu D^\mu e_R$$

$$y_0 \gamma_{\mu\nu} \bar{e}_R \sigma^{\mu\nu} e_L + y_0^* \gamma_{\mu\nu} \bar{e}_L \sigma^{\mu\nu} e_R$$

$$m_1 \bar{e}_R e_L + m_1^* \bar{e}_L e_R$$

## Interface

SandBox App

0.0.0.0:1234

Google

Symmetry Groups  
U(1)

Fields  
S = {}  
F = {e<sub>L</sub>, e<sub>R</sub>}  
V = {γ}

Lagrangian

$$-\frac{1}{4} \gamma_{\mu\nu} \gamma^{\mu\nu} + i \bar{e}_L \gamma_\mu D^\mu e_L + i \bar{e}_R \gamma_\mu D^\mu e_R$$

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$$m_1 \bar{e}_R e_L + m_1^* \bar{e}_L e_R$$

Field

Main Reprs

Main

Symbol &nu;

Subscript L

ASCII Name nuL

Spin 1/2: Fermion

Chirality left

Cancel Ok

## Interface

SandBox App

0.0.0.0:1234

Google

Symmetry Groups  
U(1)

Fields  
S = {}  
F = {e<sub>L</sub>, e<sub>R</sub>}  
V = {γ}

Lagrangian  

$$-\frac{1}{4} \gamma_{\mu\nu} \gamma^{\mu\nu} + i \bar{e}_L \gamma_\mu D^\mu e_L + i \bar{e}_R \gamma_\mu D^\mu e_R$$

$$y_0 \gamma_{\mu\nu} \bar{e}_R \sigma^{\mu\nu} e_L + y_0^* \gamma_{\mu\nu} \bar{e}_L \sigma^{\mu\nu} e_R$$

$$m_1 \bar{e}_R e_L + m_1^* \bar{e}_L e_R$$

Field

Main Reps

Representations

U(1):	0	√	1	/	1
-------	---	---	---	---	---

Cancel Ok



## Interface

SandBox App

0.0.0.0:1234

Google

G F Config

Symmetry Groups

U(1)

Fields

S = {}

F = {e<sub>L</sub>, e<sub>R</sub>, ν<sub>L</sub>}

V = {γ}

Lagrangian

$$-\frac{1}{4} \gamma_{\mu\nu} \gamma^{\mu\nu} + i \bar{e}_L \gamma_\mu D^\mu e_L + i \bar{e}_R \gamma_\mu D^\mu e_R + i \bar{\nu}_L \gamma_\mu D^\mu \nu_L$$

$$Y_0 \gamma_{\mu\nu} \bar{e}_R \sigma^{\mu\nu} e_L + Y_0^* \gamma_{\mu\nu} \bar{e}_L \sigma^{\mu\nu} e_R + Y_1 \gamma_{\mu\nu} \bar{\nu}_L^c \sigma^{\mu\nu} \nu_L + Y_1^* \gamma_{\mu\nu} \bar{\nu}_L \sigma^{\mu\nu} \nu_L^c$$

$$m_2 \bar{e}_R e_L + m_2^* \bar{e}_L e_R + m_3 \bar{\nu}_L^c \nu_L + m_3^* \bar{\nu}_L \nu_L^c$$

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# Summary

- Two Parts
  - Core
    - C++ Library
    - Nearly Complete for First Release
  - Interface
    - Browser-based
    - In a usable state (but not by users!)
- Still Need
  - Save/Read Model
  - Output FeynRules `.fr` file
  - Fine-tuning and testing of Interface