Automatic Lagrangian Generation

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with Neil Christensen, Daniel Salmon,
Christian Speckner, and Stefanus

Pheno 2012

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	$(0,\frac{1}{2})$
ℓ_L	1	2	-1	0	1	$(\frac{1}{2},0)$
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What A Model Builder Wants

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

- 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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Goals (for First Release)

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

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  } Dialog to enter and edit Symbol in Main Window

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- Functionality
  - Automatic Lagrangian Generation ◀ Display in Main Window
  - Read and Save Model
  - Output to FeynRules

  } Menu option

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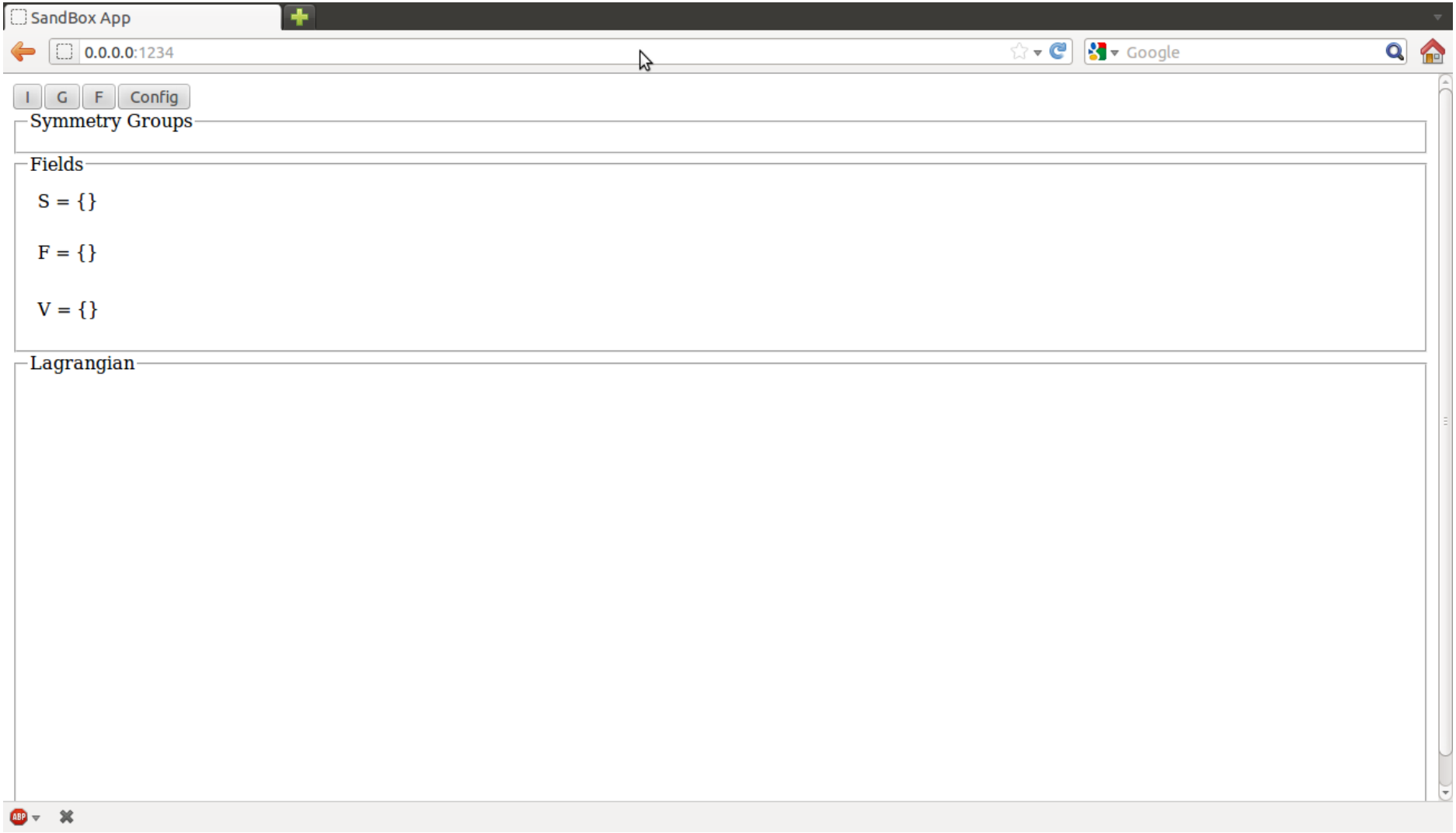
Status: Core

- 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


SandBox App
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Google
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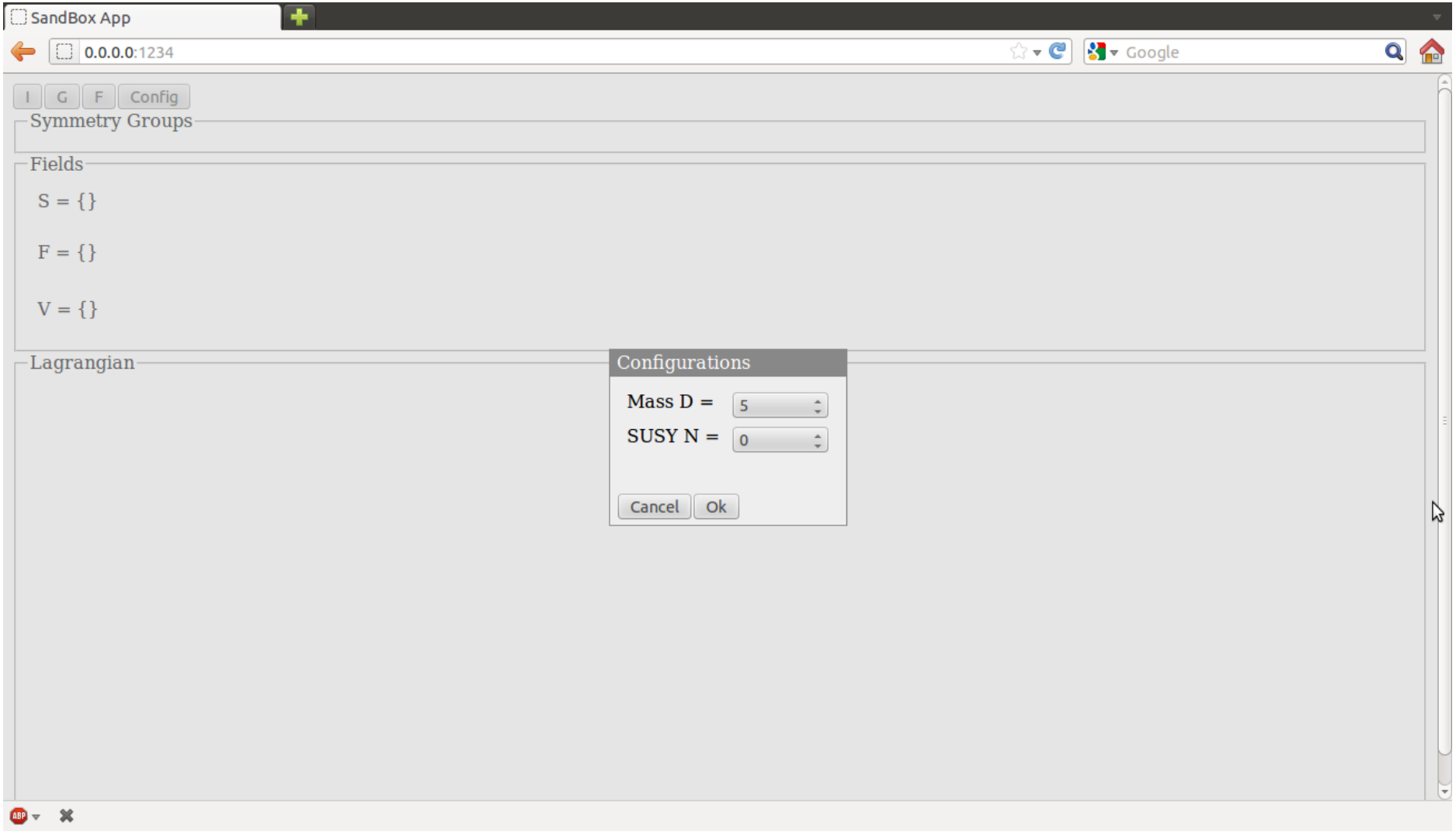
Config
Symmetry Groups
Fields
S = {}
F = {}
V = {}
Lagrangian

Interface


SandBox App
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S = {}
F = {}
V = {}
Lagrangian
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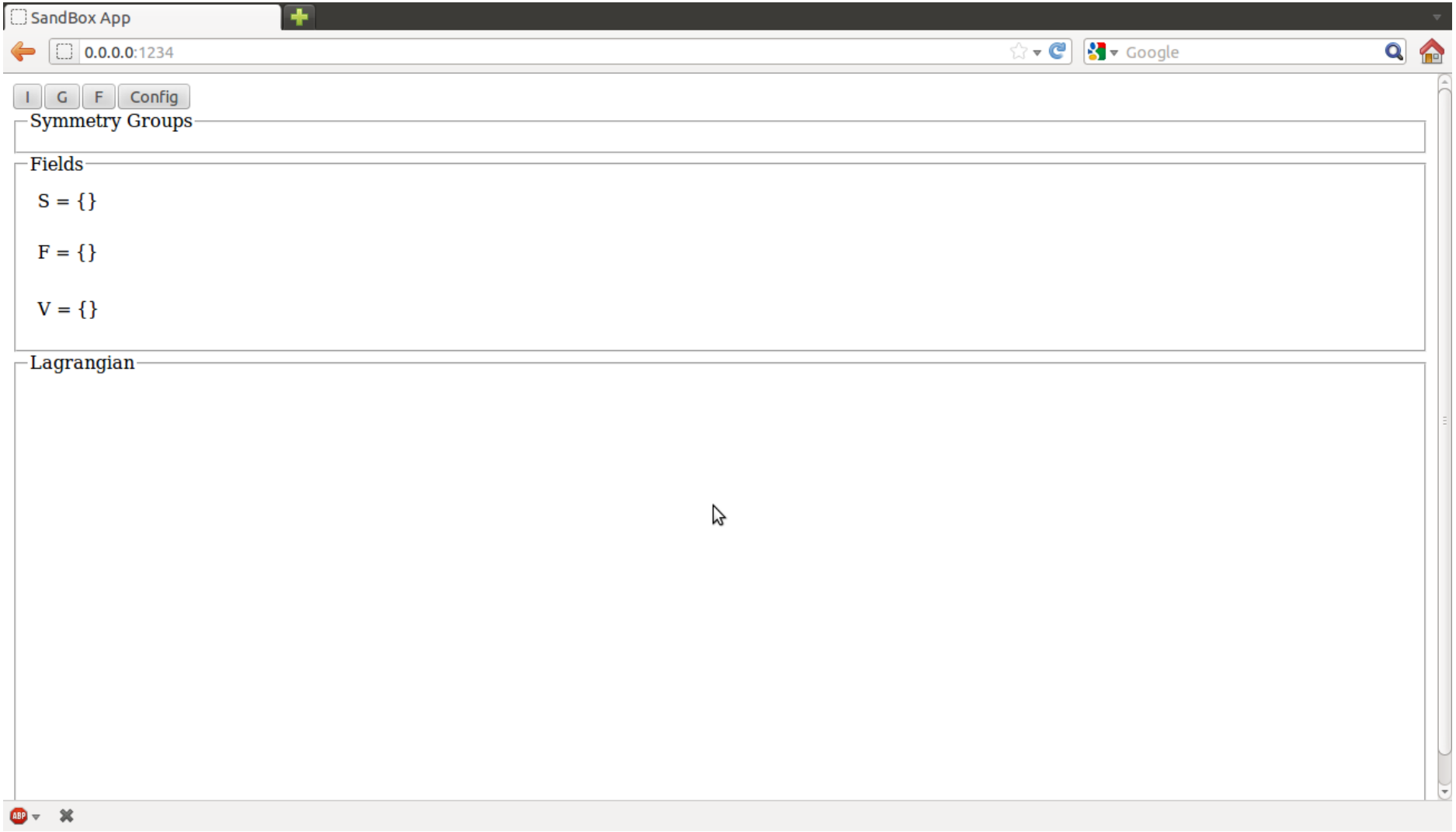
Interface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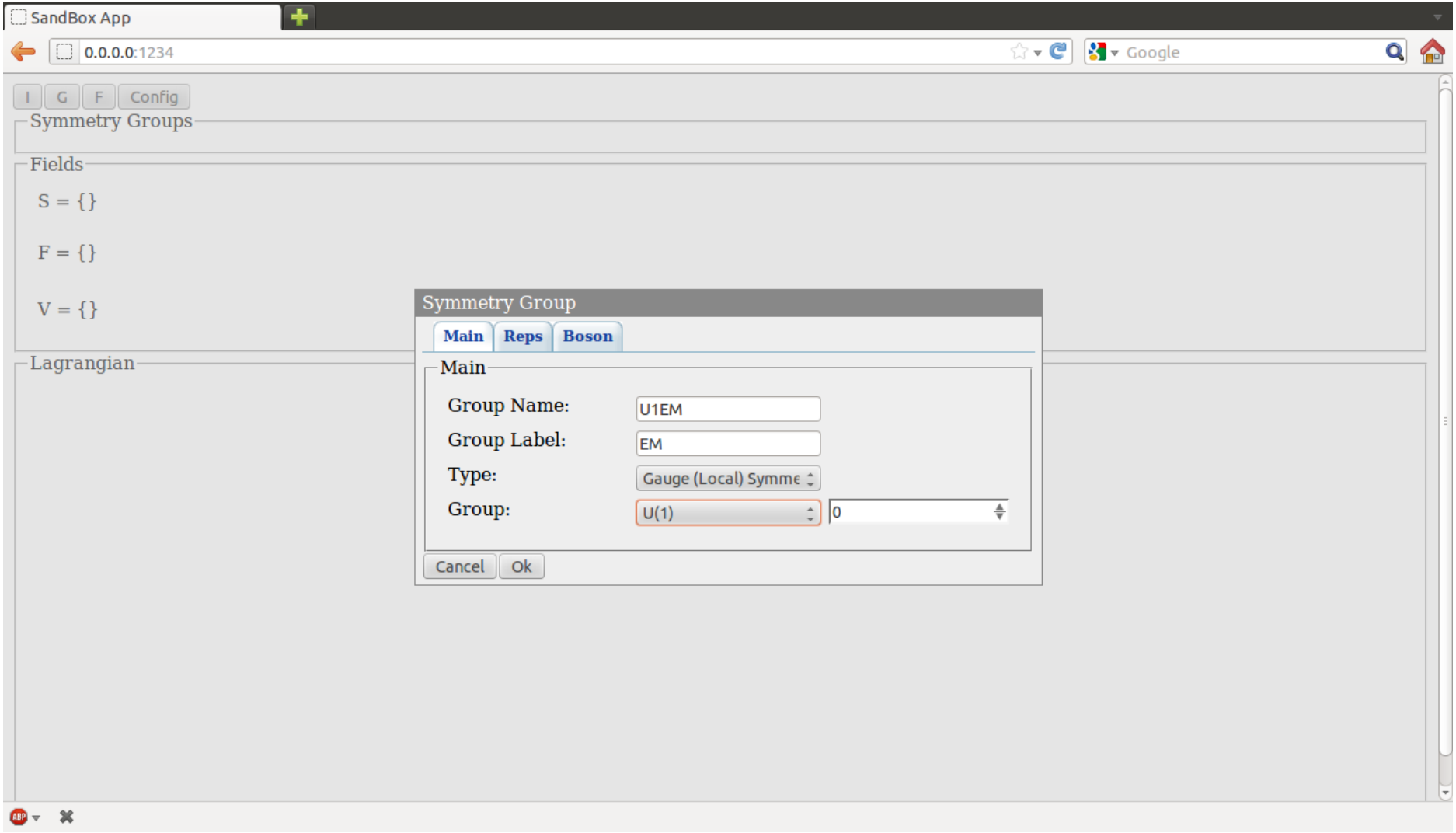
S = {}
F = {}
V = {}
Lagrangian

Interface


SandBox App
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S = {}
F = {}
V = {}
Lagrangian
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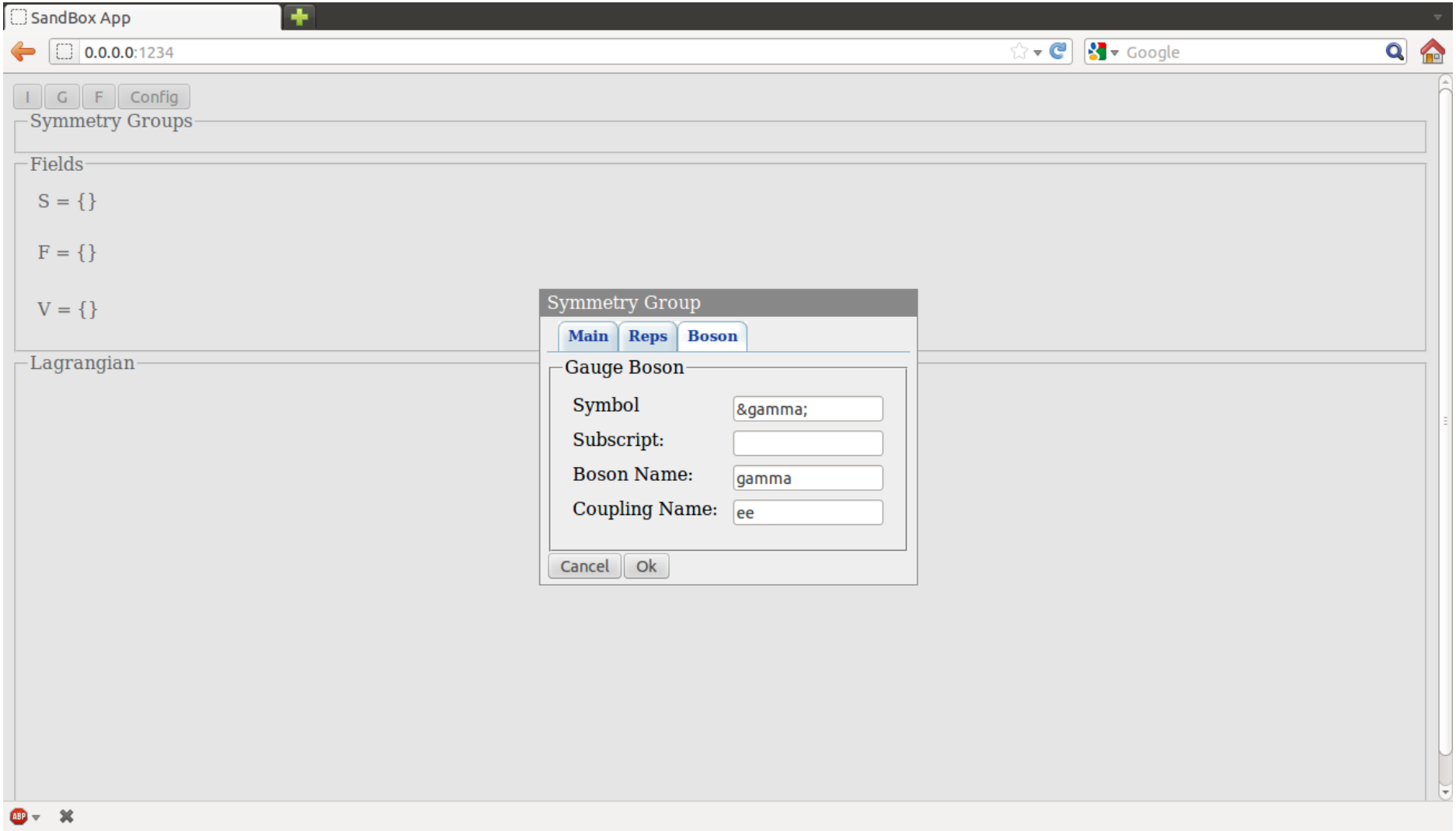
Cancel
Ok

Interface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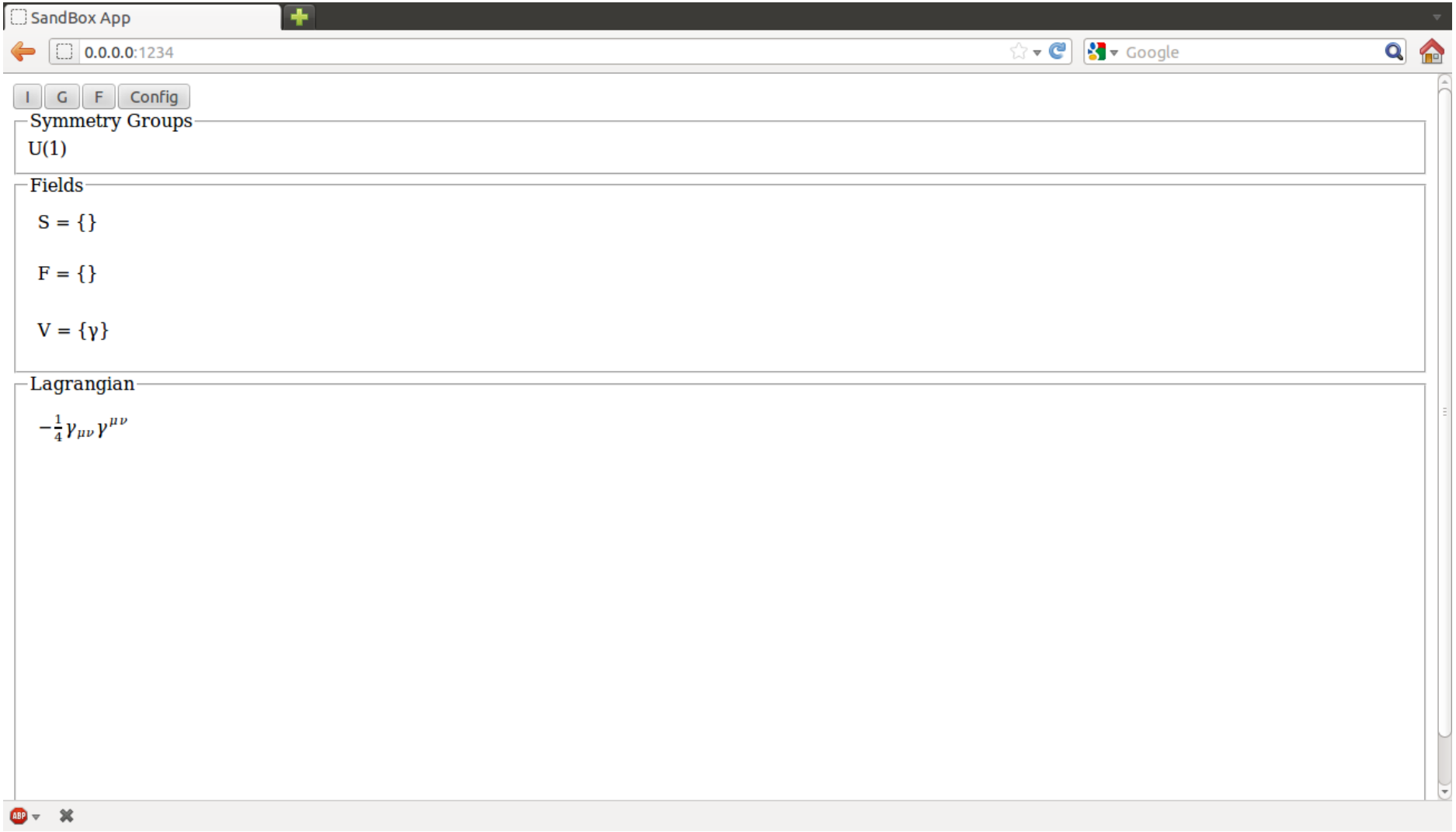
Interface


SandBox App
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Symmetry Groups
U(1)
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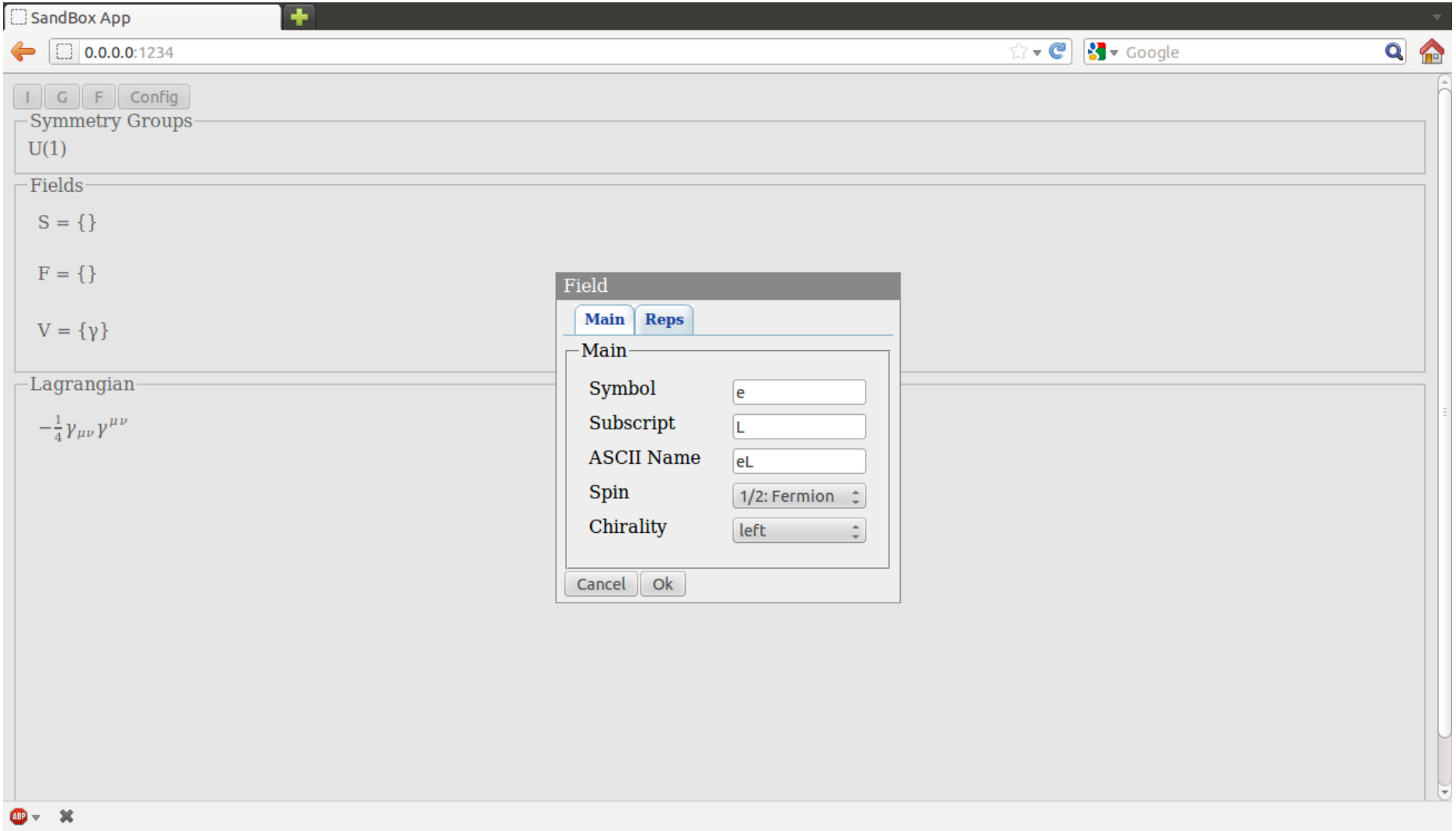
S = {}
F = {}
V = {γ}
Lagrangian
$-\frac{1}{4}\gamma_{\mu\nu}\gamma^{\mu\nu}$

Interface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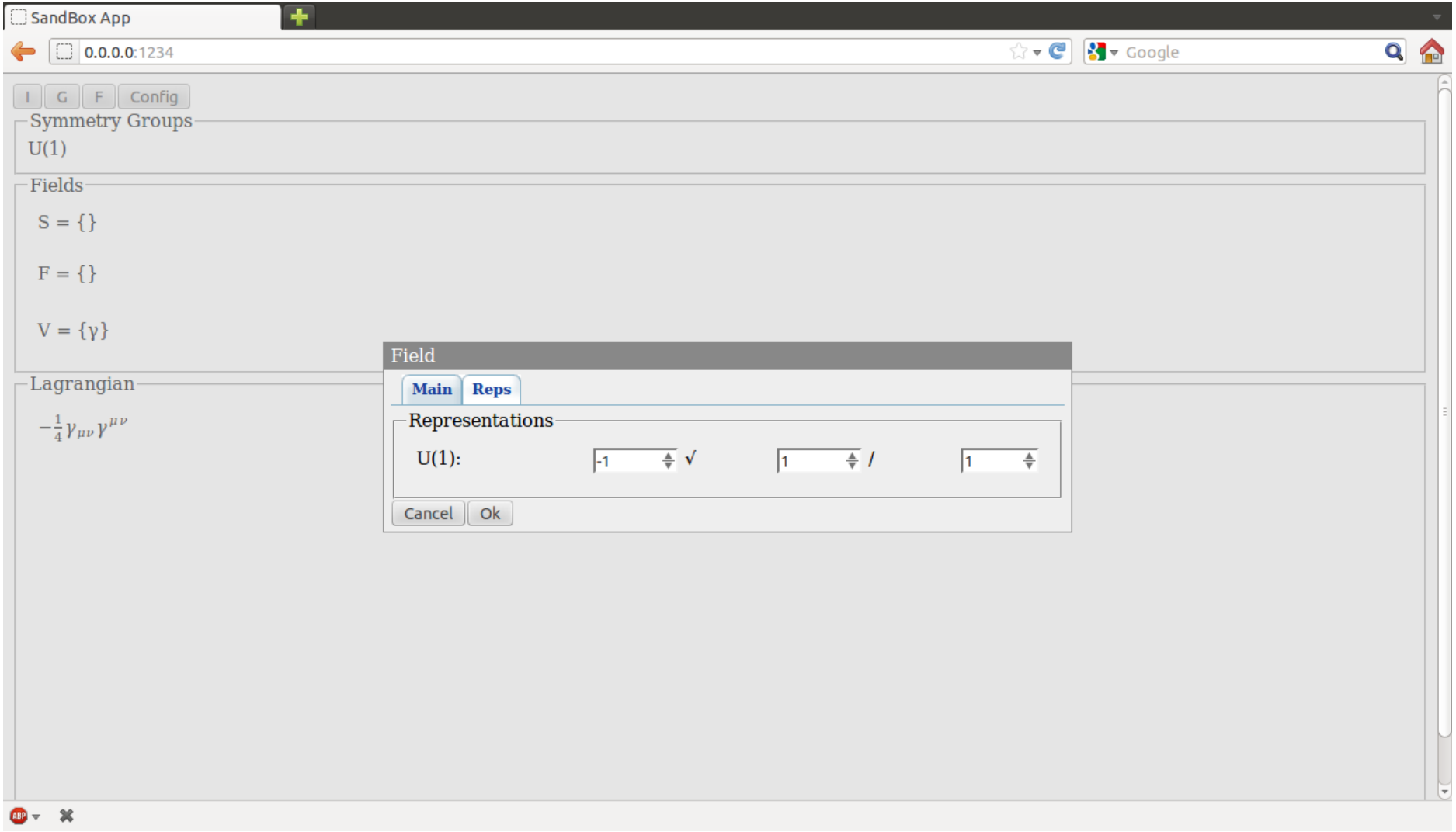
Ok

Interface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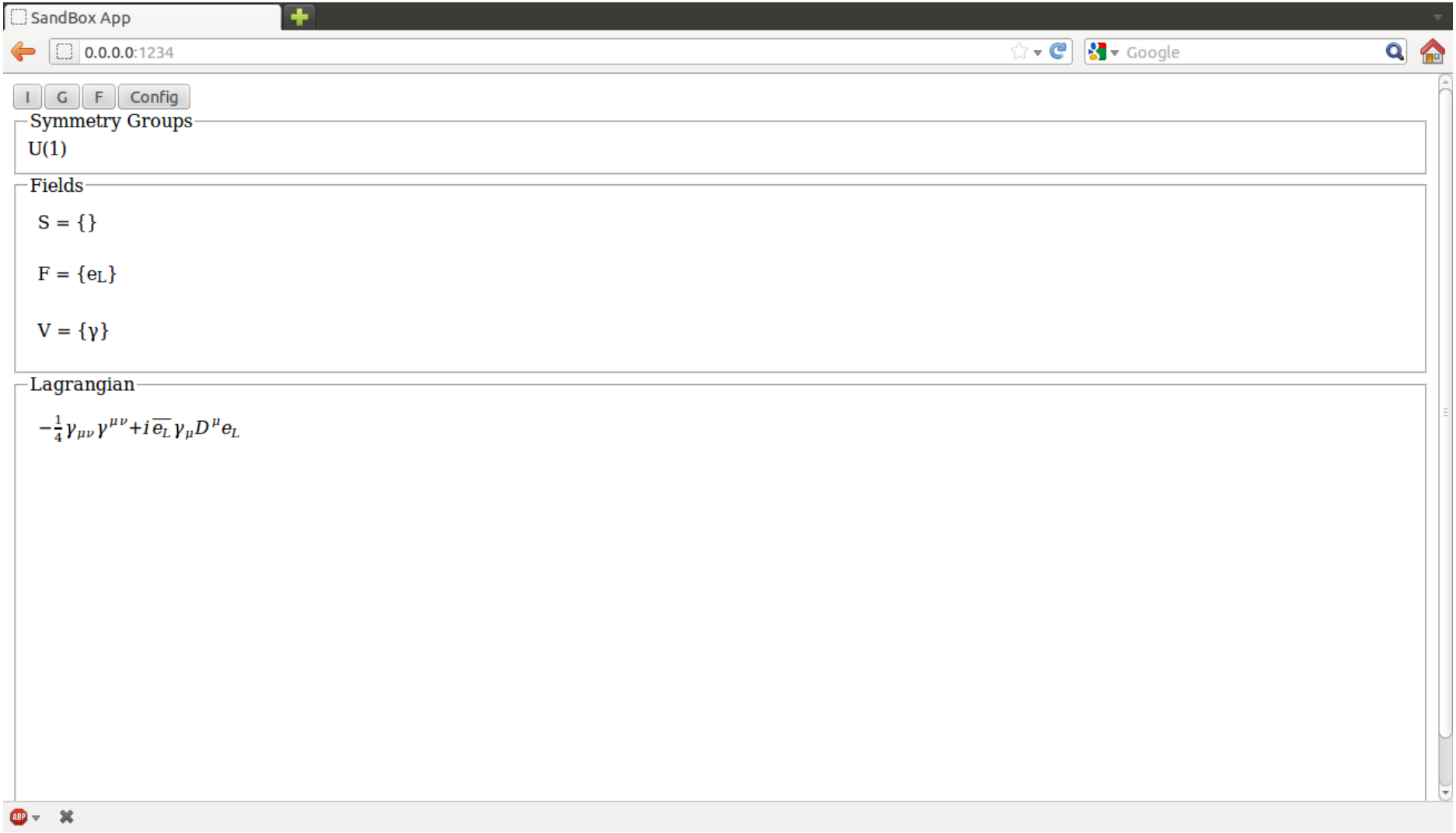
SandBox App
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S = {}
F = {e_L}
V = {γ}
Lagrangian
$-\frac{1}{4}\gamma_{\mu\nu}\gamma^{\mu\nu}+i\overline{e_L}\gamma_\mu D^\mu e_L$

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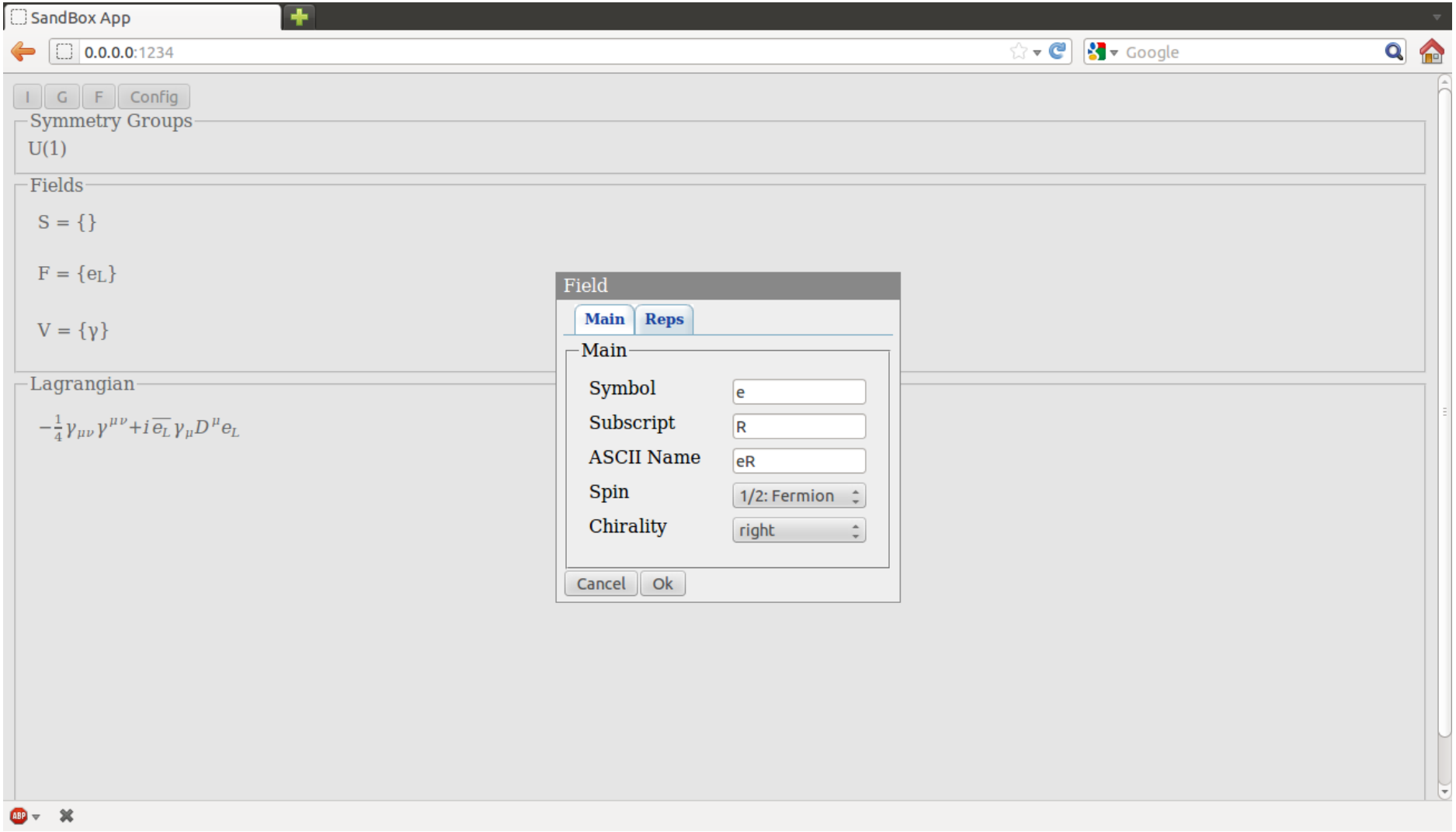
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Chirality
right
Cancel
Ok

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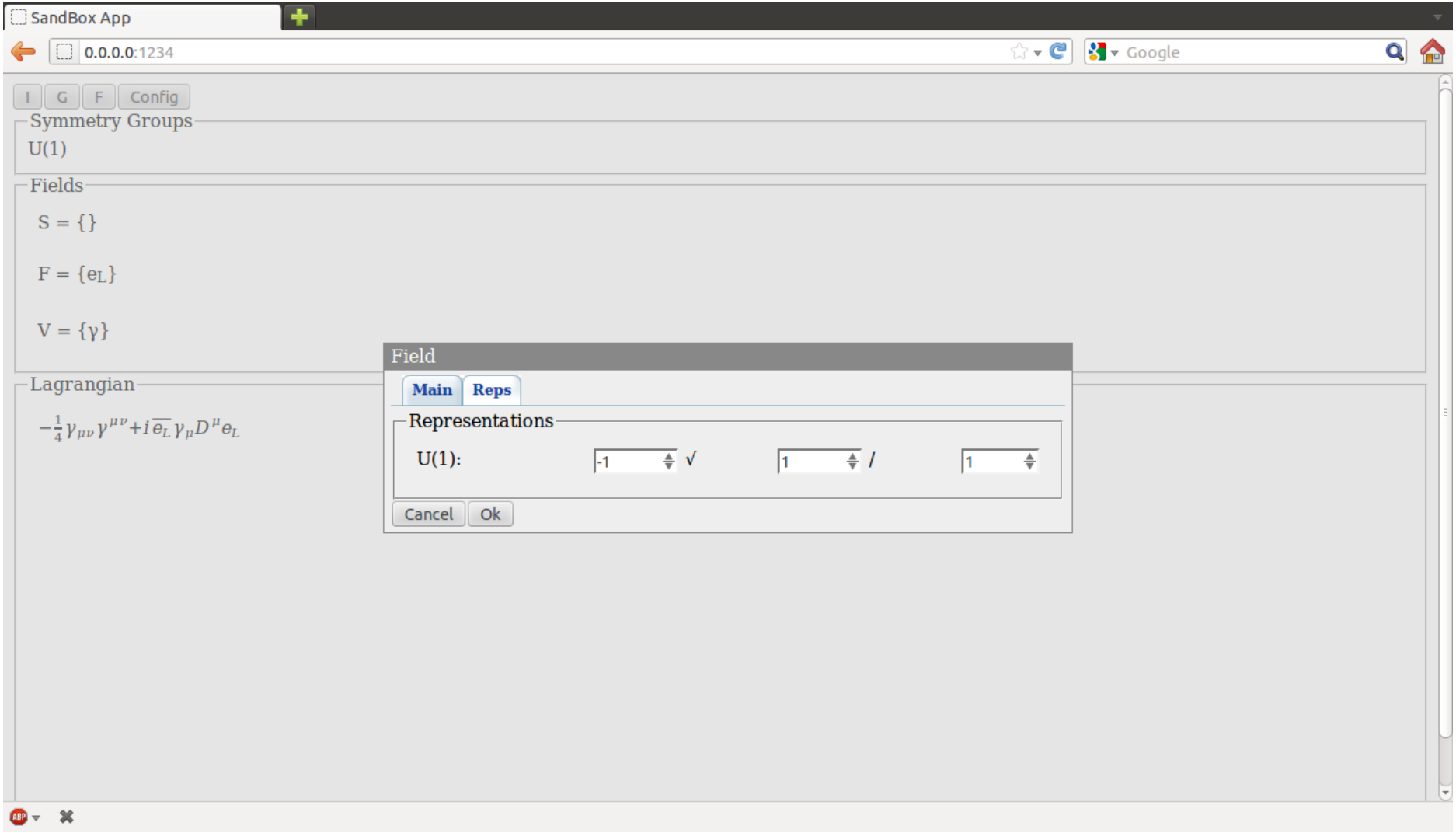
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1
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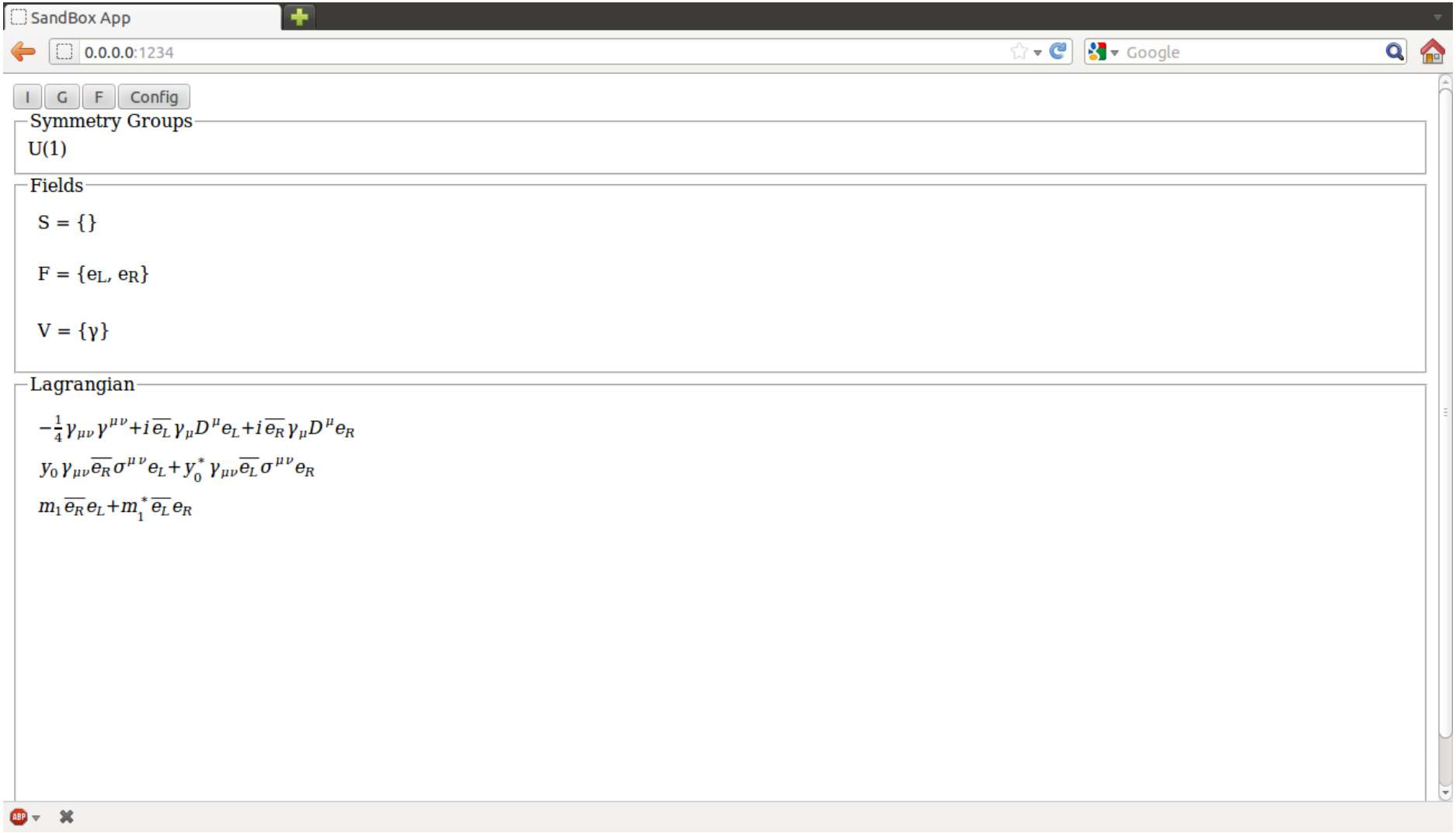
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$m_1\overline{e_R}e_L+m_1^*\overline{e_L}e_R$

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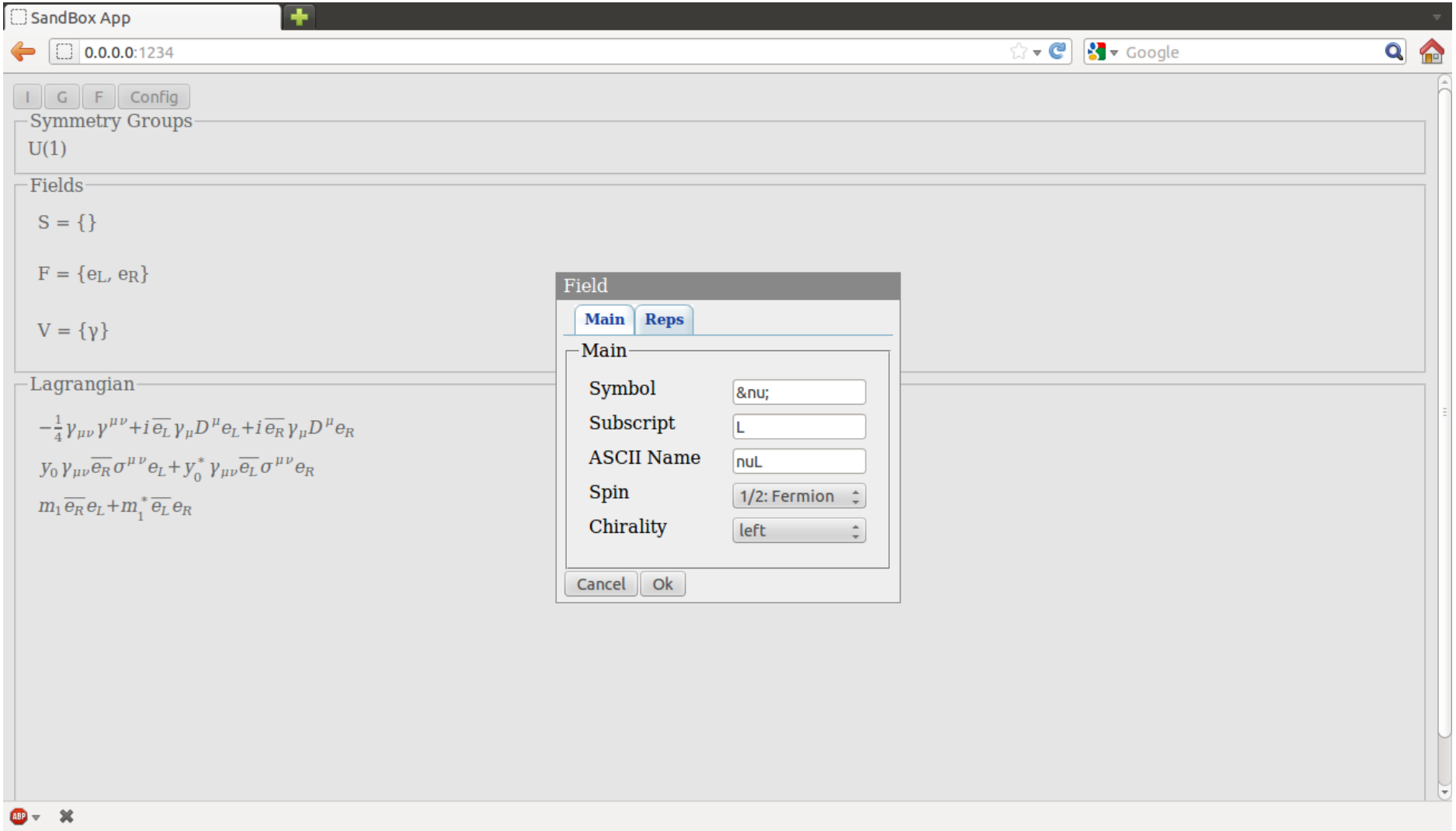
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1/2: Fermion
Chirality
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Cancel
Ok

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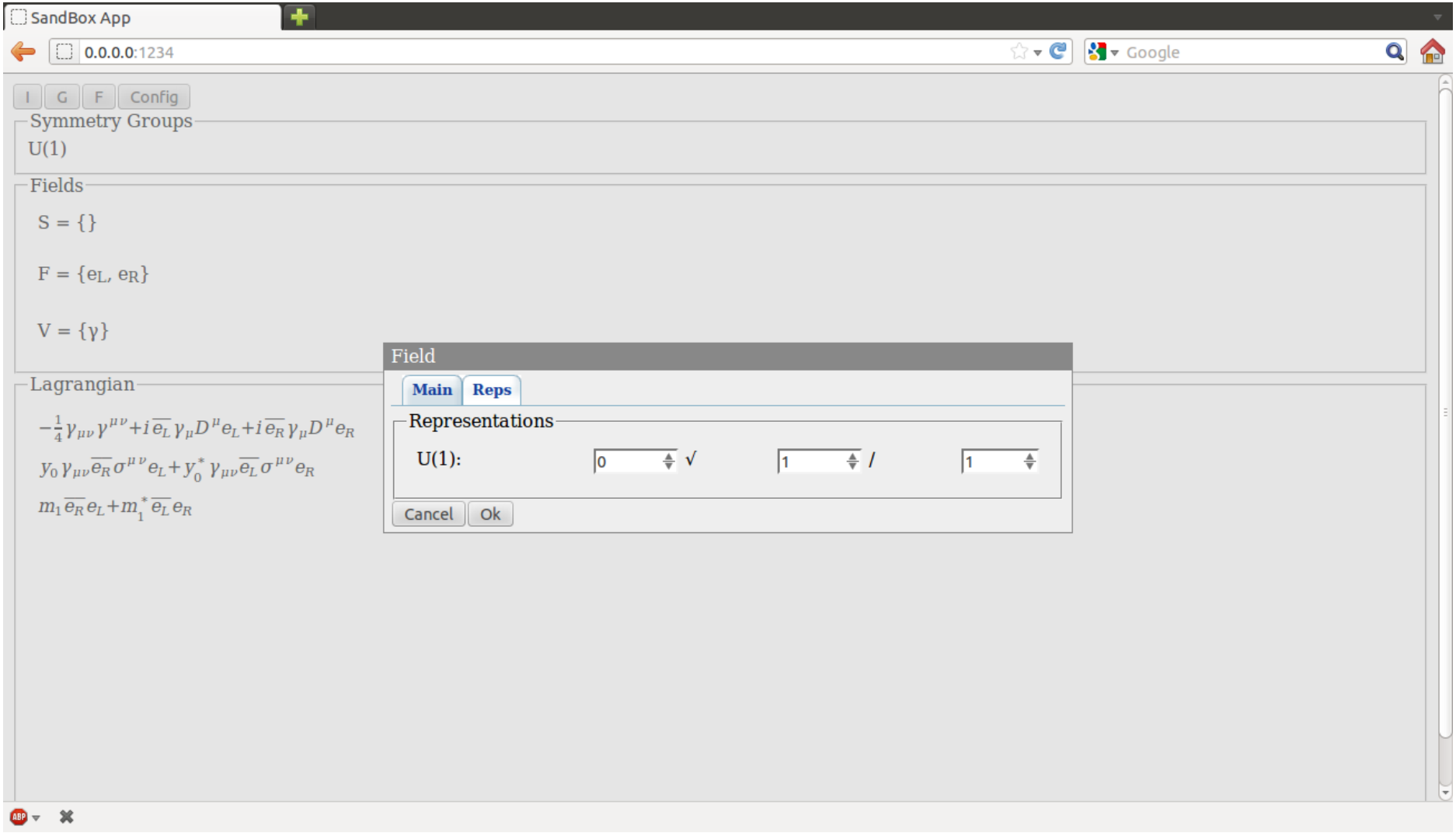
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Field
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Representations
U(1):
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Cancel
Ok

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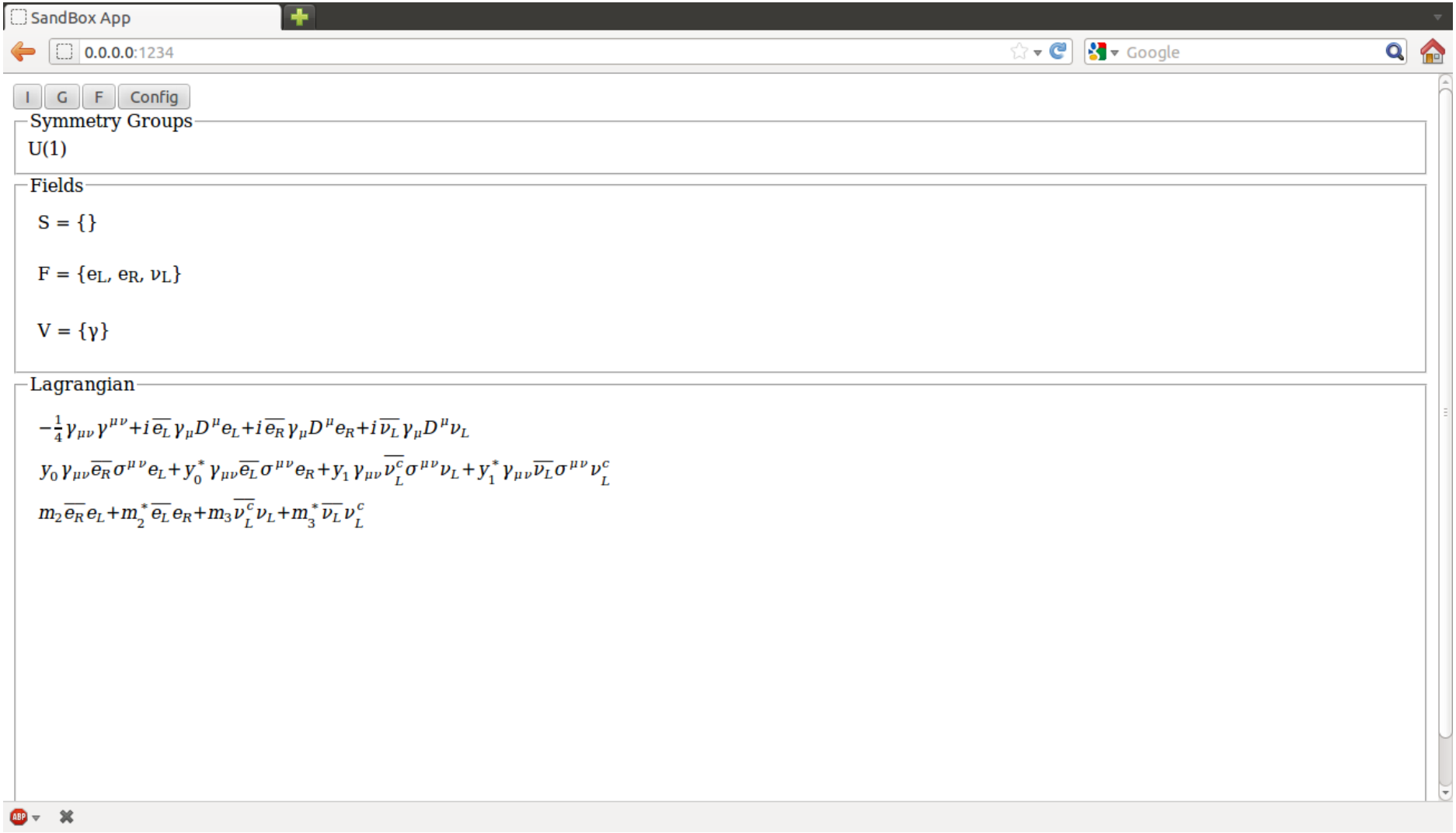
SandBox App
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Fields
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$y_0\gamma_{\mu\nu}\overline{e_R}\sigma^{\mu\nu}e_L+y_0^*\gamma_{\mu\nu}\overline{e_L}\sigma^{\mu\nu}e_R+y_1\gamma_{\mu\nu}\overline{\nu_L^c}\sigma^{\mu\nu}\nu_L+y_1^*\gamma_{\mu\nu}\overline{\nu_L}\sigma^{\mu\nu}\nu_L^c$
$m_2\overline{e_R}e_L+m_2^*\overline{e_L}e_R+m_3\overline{\nu_L^c}\nu_L+m_3^*\overline{\nu_L}\nu_L^c$

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Summary

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