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Conformal Symmetry: Finding New Physics in Scale Invariance

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I. Symmetry

Modern physics is the study of symmetry. Everything from electromagnetism to the famed Higgs mechanism stems from fundamental symmetries. These have fancy mathematical names and even fancier math behind them, but the basic idea is the same. These are mathematical generalizations of normal transformations such as rotating. These symmetries describe fields (electric, magnetic, etc.).

Most models of unification, i.e. string theory, use "Poincare symmetry." This symmetry includes both translations and rotations. This means physics only cares about relative position, angle, velocity, etc. If I were to wake up in a windowless room that had been moved a mile north and rotated 90 degrees since going to sleep, I wouldn't notice a difference.

When this symmetry is broken into its mathematical essence, and certain assumptions are made, it turns into General Relativity. If there is another fundamental symmetry of the universe, perhaps it leads to new physics as well.

II. Conformal Symmetry

There is an extra symmetry, changes of scale. When combined with translations and rotations this is called "conformal symmetry".

Imagine a balloon with two people drawn on it. One an inch tall and the other two inches tall; when the balloon is blown up, the former is five inches, the latter is ten. The second person is still twice as tall, everything is proportioned the same; these "people" would not notice any difference. Likewise, if the solar system were to become ten times larger, life would go on unchanged (though astronomers would be confused).

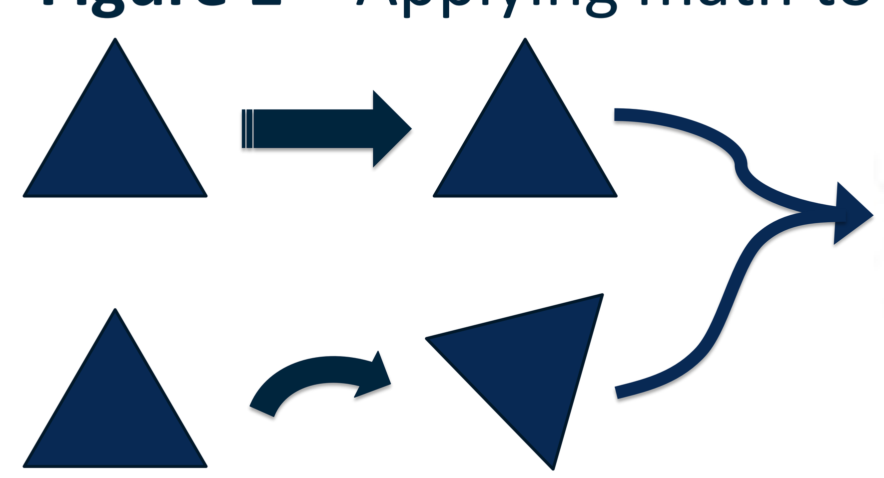
III. Results

The proper treatment of conformal symmetry gives a theory of gravity that reduces to general relativity, but it also gives a time dimension and extra fields.

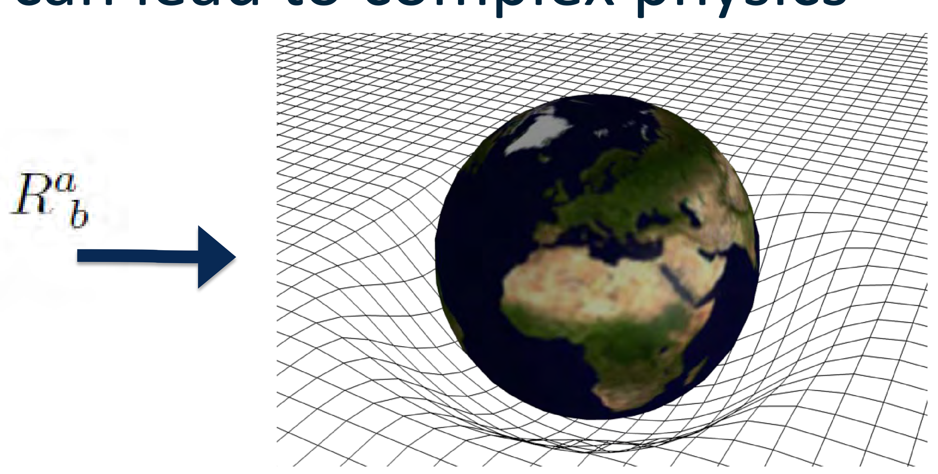
Most theories assume time in the beginning, but my work allows the natural mathematical structure of the symmetry to create time.

The standard model tacks different symmetries together to explain physics. My work has successfully lead to a model of gravity that naturally includes an electroweak interaction (what the Higgs discovery was about) without assuming there are extra dimensions of spacetime.

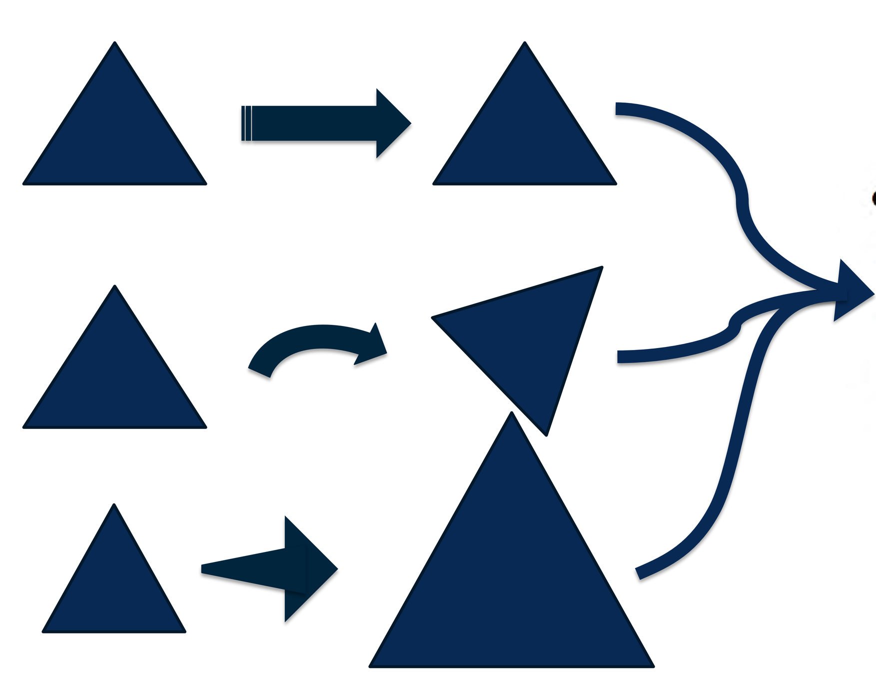
Figure 1 – Applying math to a simple symmetry can lead to complex physics



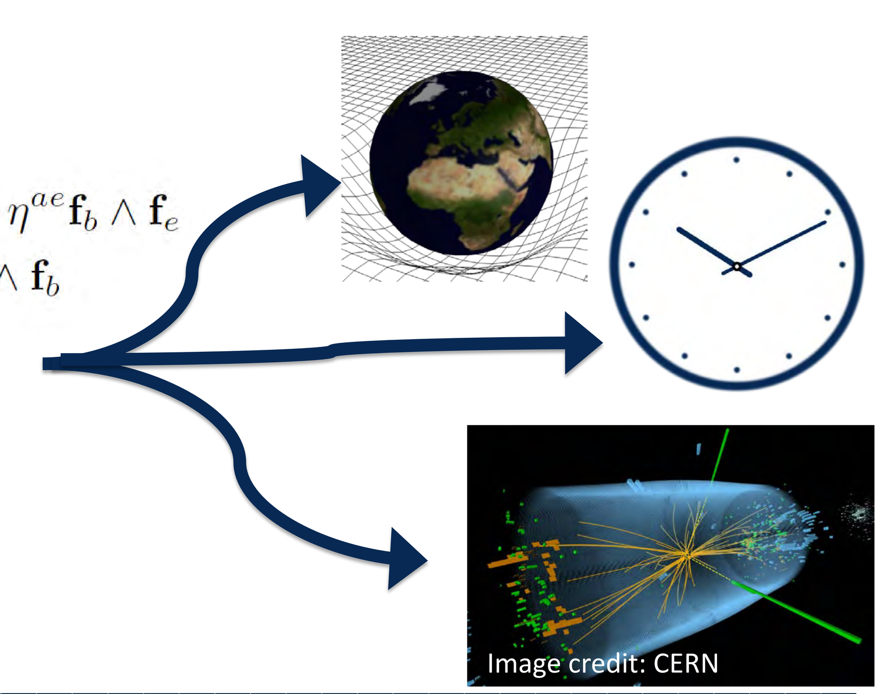
$$d\omega^a_{\ b} = \omega^c_{\ b} \wedge \omega^a_{\ c} + R^a_{\ b}$$
$$de^a = e^b \wedge \omega^a_{\ b}$$



(A) Translations and rotations lead to gravity

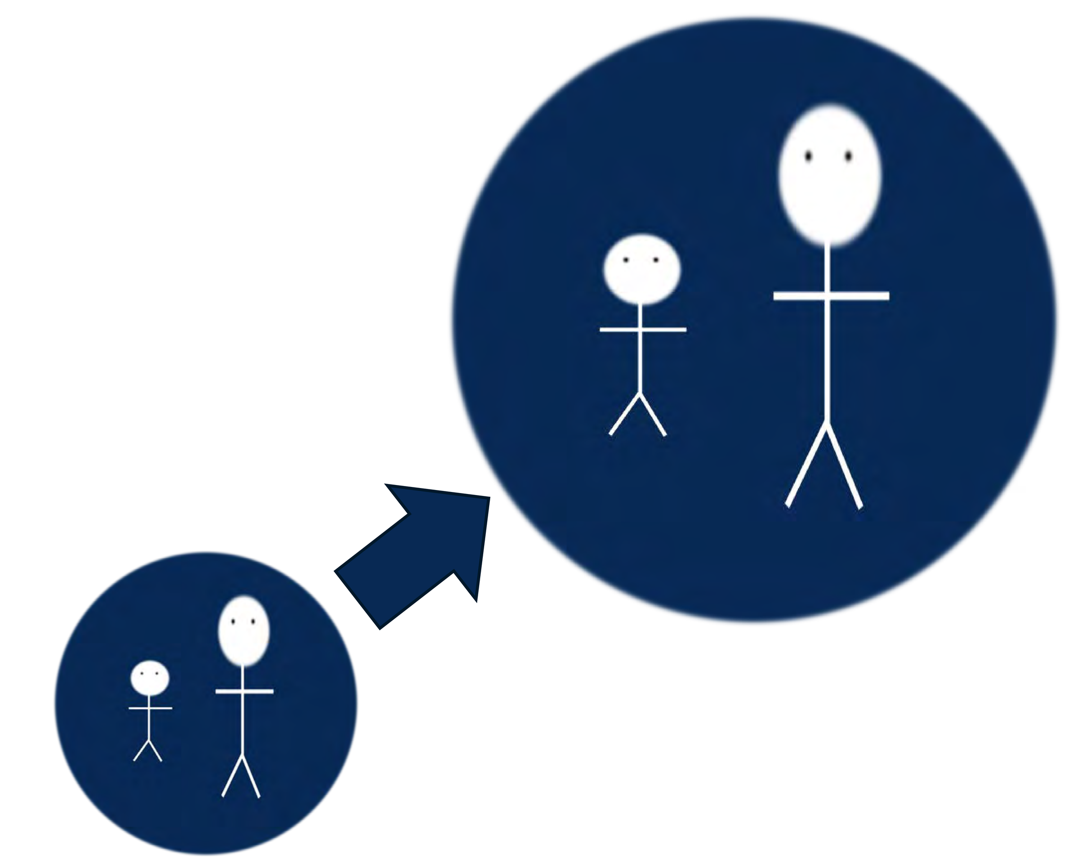


$$\mathbf{d}\boldsymbol{\omega}^a_{\ b} = \boldsymbol{\omega}^c_{\ b} \wedge \boldsymbol{\omega}^a_{\ c} + 2\Delta^{ad}_{cb}\mathbf{f}_d \wedge \tilde{\mathbf{e}}^c - \eta^{ae}\mathbf{f}_b \wedge \mathbf{f}_e$$
$$\mathbf{d}\tilde{\mathbf{e}}^a = \tilde{\mathbf{e}}^c \wedge \boldsymbol{\omega}^a_{\ c} + \boldsymbol{\omega} \wedge \tilde{\mathbf{e}}^a - \eta^{ab}\boldsymbol{\omega} \wedge \mathbf{f}_b$$
$$\mathbf{d}\mathbf{f}_a = \boldsymbol{\omega}^c_{\ a} \wedge \mathbf{f}_c + \mathbf{f}_a \wedge \boldsymbol{\omega}$$
$$\mathbf{d}\boldsymbol{\omega} = \tilde{\mathbf{e}}^c \wedge \mathbf{f}_c$$



(B) Conformal symmetry leads to gravity, time, and an electroweak interaction

Figure 2 – Changes of scale are unnoticeable to "local observers"



"People" drawn on a balloon would not notice a difference if the balloon was blown up larger.

IV. Conclusions

By carefully evaluating what can be known about the world, it is possible to determine the fundamental symmetries of the universe. By taking these symmetries to their full mathematical extent, they often lead to new physics.

New physics leads to a better understanding of the universe, and to new innovations that improve life and create economic growth.

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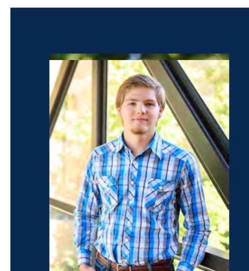

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