Are Symmetry Explanations Grounding Explanations?

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Roadmap

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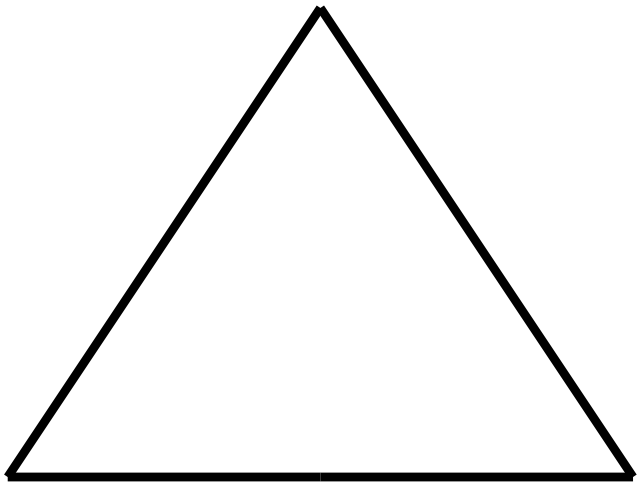

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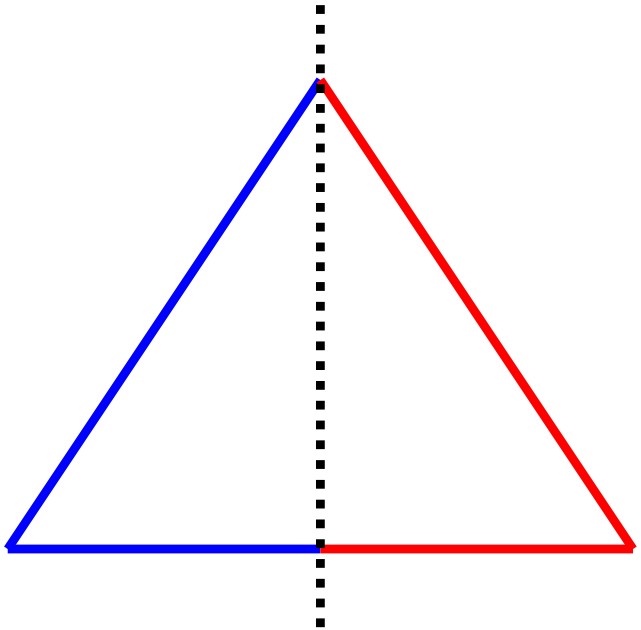

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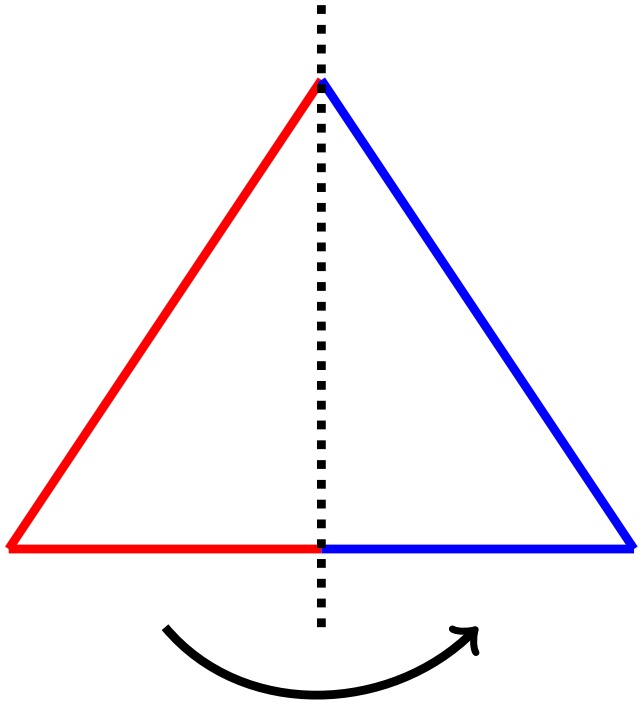

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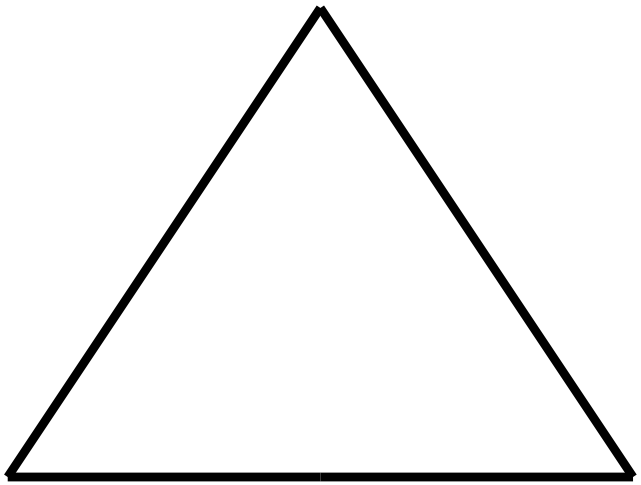

Symmetry Transformations: Newtonian Position

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- Lange (2016) claims that symmetry principles are *metalaws*: laws governing the laws.
- A metalaw is a law that is a member of a nomically stable set
  - a set of propositions Γ is *nomically stable* if and only if, for any p logically compatible with Γ and any $q \in \Gamma$, $\neg(p\diamond \rightarrow \neg q)$

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- Recall that a *symmetry principle* is a constraint on the laws, which states that all laws are invariant under a particular symmetry transformation.
- I take spacetime structure to consist in subnomic facts: specifically in the metric of distance between spacetime points.

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  - P1 Spacetime is not Minkowski (except locally) and the laws are not Lorentz invariant (except locally).
  - P2 Strong Centering: if P and Q are true in the actual world, P$\Box\!\!\rightarrow$ Q

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Question: Does this mean that the Lorentz transformations are not nomically stable? After all, Spacetime not being Minkowski is logically compatible with the Lorentz transformations not holding.

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- But it might be that spacetime is not Minkowski and

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- Claim: this an inference to the best explanation.
- If it is, then the underlying structure must explain the symmetry principle.

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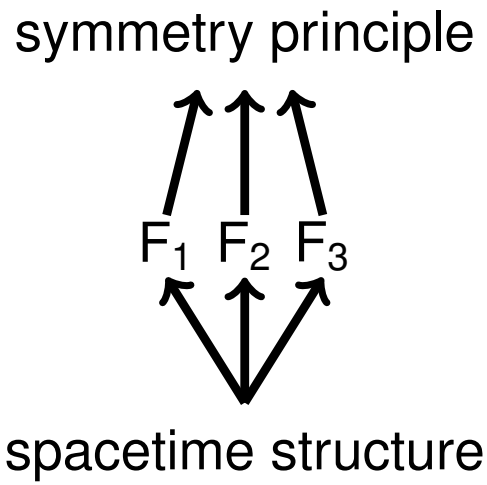
- Plausibly, forces are *relations* between objects, and these relations are mediated by spatiotemporal relations.
- More plausibly, forces are grounded in fields, where fields are properties of spacetime points and their structure dependent on spatiotemporal structure.
- This suggests that interactions are invariant under symmetry transformations because those describe the spatiotemporal structure that grounds those interactions.

The Grounding Picture

- On this picture, spacetime structure grounds the force laws (or fields). These then ground the symmetry principle.



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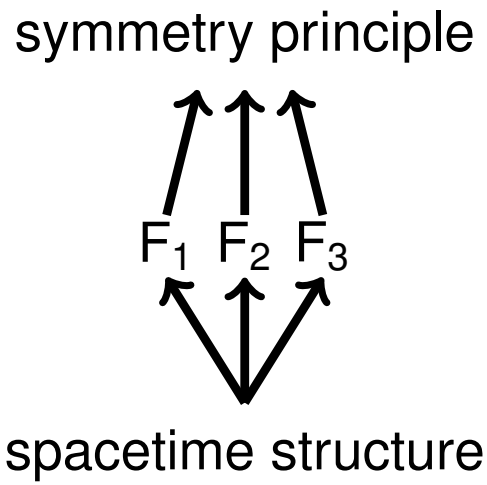
- The principle is not an accident, but neither does it govern the forces or field interactions.



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- Noether's theorem shows that for any continuous variational symmetry of a Lagrangian, there is a conserved quantity.
- Worth noting: there is a inverse Noether's theorem, which shows that for every conserved quantity there is a variational symmetry.

Explanatory Options

Are the Noether theorems *explanatory*? There are three dominant answers to this question:

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- Yes: The symmetries explain conservation laws by *governing* them. The symmetries are *metalaws*.
- Yes: The symmetries explain conservation laws by *grounding* them.
- No: Both symmetries and metalaws are grounded by the dynamics. The Lagrangian explains it all.

The Grounding Picture Again

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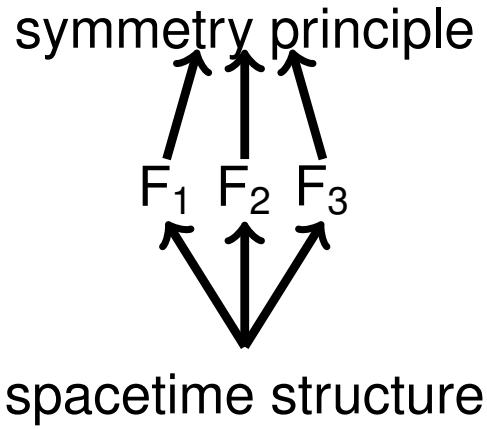

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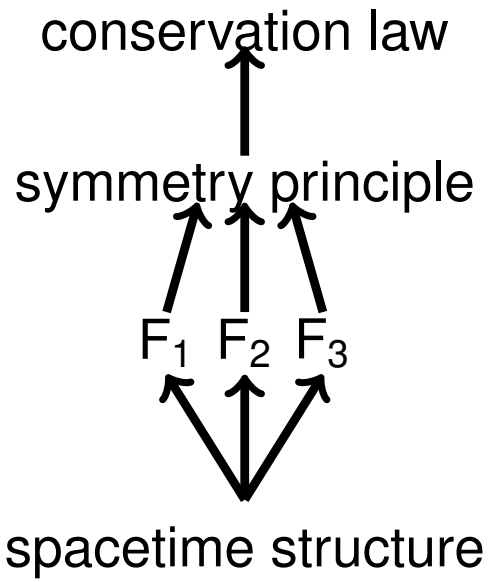
- Or rather: the symmetries describe the featues of the underlying spacetime structure that grounds the fact that these quantities are conserved.



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Conclusions

- I've presented two arguments that symmetry principles are explained by non-nomic facts about spacetime structure.
- I've suggested that this explanation is best understood as a grounding explanation.
- I've suggested that this grounding explanation can be extended to the explanation of conservation laws by symmetry principles.