Symmetries and Subsystems

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The ways of encoding the content of laws that are most appealing to mathematicians and physicists appear to lead to notions of symmetry that are coolly indifferent to considerations of representational equivalence. (Belot, 2013)

The Unobservability Thesis: Given a family of models of a system which are related by a symmetry transformation, it is impossible to determine empirically which model in fact represents the system.

The Representational Equivalence Thesis: Given a family of models of a system which are related by a symmetry transformation, insofar as one model successfully represents a system, so do all the others.

The Surplus Structure Thesis: Given a theory with a symmetry transfor- mation, insofar as the symmetry falls short of being an automorphism of the mathematical structures used to define the theory's models, then this points to aspects of that structure which are redundant, do no representational work, and can be removed from the theory without loss.

The Modal Equivalence Thesis:
Two states of affairs related by the action of a symmetry transformation are really the same state of affairs, differently described.

"*The Unobservability Thesis would seem to imply that radiation frequency is undetectable, so that no observation can distinguish visible light from X-rays, and this is obviously absurd. But it is obvious why it is absurd: because the conformal symmetry is only a symmetry of radiation in the absence of matter, and ceases to be a symmetry of systems in which matter is present.*" (p. 11)

A symmetry group G with action R is **subsystem-specific** if it has no extension to a symmetry of the combined system; **subsystem-local** if G with action $R \times Id$ is a symmetry of the combined system; **subsystem-global** if G with action $R \times R'$, with R' non-trivial, is a symmetry of the combined system.

Wallace's Answers to the Questions:
If G is a group of **non-extendible** dynamical symmetries then no conclusions about observational, representational, or modal equivalence follow from the symmetry.

If G is a group of **extendible** dynamical symmetries then G-variant features of a system are unobservable from within that system and surplus, and symmetry-related structures are representationally equivalent.

If in addition G is a group of **subsystem-global** dynamical symmetries then G-variant features of a system can be measured from outside that system, but any such measurement can be reinterpreted as a measurement of a G-invariant relation between system and measurement device, and a symmetry transformation leaves the **intrinsic** features of a system invariant but changes its system-**extrinsic** features, and symmetry transformations bring about new possibilities.

If instead G is a group of **subsystem-local** dynamical symmetries then G-variant features of a system are unobservable, and a symmetry transformation of an entire system does not bring about a new possibility, and does not change any physical features of the system.

"*The results of this paper go some way towards seeing how genuinely substantive intepretative results can follow from a purely formal concept of symmetry. But a puzzle remains: my analysis turns on how a symmetry can be extended beyond a system to other systems* *in dynamical contact with it, and definitionally no formal feature of a system's symmetries can fix this question of extension to other systems.* ***If so, then once again we seem to need to make substantial interpretative assumptions in order to get interpretative results from a theory's symmetries, and to abandon the hope of extracting such results from a formal conception of symmetry.***" (p. 32)

Questions:
As Penrose was quoted saying above: asymptotically flat solutions provide idealized models of relatively isolated self-gravitating subsystems of our universe. So it may well seem that in this context it is safe to fall in with the account that symmetries are to be understood as generating new possibilities when they act on the state of a subsystem of the universe, but not when they act on global histories. And then we can set aside these funny asymptotic symmetries as irrelevant, and go back to flat-out denying that generalized shifts generate new possibilities. Well—there is much that is controversial in this line of thought. In particular, *its presupposition that a family of solutions is worth taking interpretatively seriously only if it offers realistic models of actual phenomena.* (Belot, 2018)

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