Section 3

Duality, Equivalence and Emergence

Organizer: Sebastian De Haro (Cambridge and Amsterdam)
Participants: Elena Castellani (Florenz), Laurenz Hudetz (Salzburg), James Read (Oxford), Laura Wells (University of Notre Dame)

Abstract:

In this symposium, we propose to start a programme for the study of dualities, equivalence and emergence which goes beyond the specific interests of these notions for the philosophy of spacetime, and addresses them by making an extensive use of the available philosophical tools. The workshop will address the following topics:

(1) Implications of dualities for philosophical accounts of emergence.

(2) Implications of the phenomena of emergence and duality for questions of fundamental ontology in physics.

(3) Recent semantic and syntactic construals of theoretical equivalence.

Titles and Abstracts of the talks

1.
Elena Castellani and Sebastian De Haro: Duality, equivalence, and emergence
Duality and emergence are two notions in an intriguing relation: on the one hand, they seem to be closely connected; on the other, they are clearly distinct—perhaps even mutually exclusive? Duality entails theoretical (formal, or representational) equivalence, while emergence, by contrast, assumes a representational asymmetry. We will discuss a number of mechanisms which lead to such an asymmetry and spell out whether, and how, duality and emergence can coexist. In particular, we will consider three cases of duality, which are of great relevance in today's theoretical physics: weak-strong duality (or S-duality), boson-fermion duality, and gauge-gravity duality.

2.
Laurenz Hudetz: Duality from a logical point of view
Recently, philosophers of physics have introduced a new notion of duality of physical theories (Butterfield 2014; De Haro, Butterfield & Teh 2016). This notion of duality – call it 'Butterfield-duality' – is defined for physical theories of the form (S,Q,D), where S is a state space, Q a set of quantities and D a dynamics. I will show (a) how Butterfield-duality is related to generalised definitional equivalence (Morita equivalence) as well as categorical equivalence and duality and (b) how Butterfield-duality can be generalised in order to be applicable to other kinds of theories by making a transition from algebras of quantities to concept algebras, which are well-studied in algebraic logic.

3.
James Read: Motivating dualities

There is an emerging consensus that for theories related by a duality, dual models typically may be taken ab initio to represent the same physical state of affairs, i.e. to correspond to the same possible world. I question this consensus, by drawing a parallel with Möller-Nielsen's recent distinction between interpretational and motivational approaches to symmetries. I draw the lesson that dual models may only be regarded as physically equivalent once a perspicuous understanding of their common ontology is secured.

4.
Laura Wells: Why surplus structure is not superfluous
The idea that gauge theory has `surplus' structure poses a puzzle: in one much discussed sense, this structure is redundant; but on the other hand, it is also widely held to play an essential role in the theory. In this paper, we employ category-theoretic tools to solve this puzzle. We precisify what is meant by `surplus' structure by means of functorial comparisons with equivalence classes of gauge fields, and then show that such structure is essential for any theory that represents a rich collection of physically relevant fields which are `local' in nature.