# AGPhil 2: "Condensed Metaphysics" II: Specific Models

The Metaphysics of Condensed Matter and Complex Systems. Brigitte Falkenburg & Margaret Morrison

Time: Monday 14:30–18:00 Location: E 020

**Invited Talk** AGPhil 2.1 Mon 14:30 E 020

**Ising Models: Interpretational and Computational Issues** — •Paul Humphreys — Department of Philosophy, University of Virginia, Charlottesville, USA

The class of models that includes Ising models, Potts models, spin glass models and related mathematical objects have been used to model many different condensed matter phenomena. Taking the canonical example of ferromagnetic phase transitions, I shall explore the sense in which Ising models represent real ferromagnets and how and why such a simple model can be successful. Central to this exploration will be the finite dimensional/infinite dimensional comparison and the extent to which relaxing the idealizations of the model ('de-idealizing* it) makes the model more or less accurate. I shall also suggest ways in which Istrail's 2000 proof that computing the partition functions (and hence the exact energy levels) for finite sublattices of non-planar 3D and 2D Ising models are NP-complete problems and Mu et al.'s 2008 result that there are macroscopic properties the values of which cannot be effectively predicted solely on the basis of knowledge of microstates of the system affect what can be known about these models.

**Invited Talk** AGPhil 2.2 Mon 15:15 E 020

**How Do Quasi-Particles Exist?** — •Brigitte Falkenburg — Institut für Philosophie und Politikwissenschaft, Fakultät 14, TU Dortmund, D-44221 Dortmund

Quasi-particles emerge in solids. In the context of the debate on scientific realism, their concept is puzzling. Quasi-particles are fake entities rather than physical particles. But they can be used as markers etc. in crystals. Hence, it is possible to use them as technologcal tools,even though in a certain sense they do not exist. It has been argued that for this reason they counter Ian Hacking's reality criterion, "If you can spray them, they exist." However, this line of reasoning misses the crucial point that quasi-particles are real collective effects of the constituents of a solid. In order to spell out the way in which they indeed exist, their particle properties are discussed in detail. It is instructive to compare their particle properties with those of ubatomic matter constituents, on the one hand, and the field quanta of a quantum field, on the other hand. All these particle properties are weaker than the classical particle properties. Their discussion sheds light on the way in which quantum phenomena in general exist, and on the specific way in which quasi-particles exist.

**Coffee break**

**Invited Talk** AGPhil 2.3 Mon 16:30 E 020

**Is the Quantum Theory of Laser Radiation a Mechanistic Theory?** — •Meinard Kuhlmann — Institut für Philosophie, Universität Bremen

The quantum theory of laser radiation explains the behavior of laser light in a way that clearly seems at variance with the mechanistic model of explanation. First, as it is typical for complex systems, the detailed behavior of the component parts plays a surprisingly subordinate role. And second, being quantum objects these "parts" are not even individual things with determinate spatio-temporal properties. I want to show that despite of these apparent obstacles the quantum theory of laser radiation is a perfect example for a mechanistic explanation in a quantum physical setting, provided one adjusts the notion of mechanisms appropriately. One may presume that these adjustments are ad hoc and question-begging. However, I will lay out that the necessary adjustments are far more natural and less drastic than one may expect.

**Invited Talk** AGPhil 2.4 Mon 17:15 E 020

**Decoherence and the Emergence of a Joint Distribution** — •Stephan Hartmann — TiLPS, Tilburg University, Tilburg, The Nethrlands

Bell states and other entangled states exhibit correlations that cannot be accounted for by a non-contextual local hidden-variable model. Various authors have shown that the non-existence of a non-contextual local hidden variables model entails that there is no joint probability distribution over random variables that represent the observables in question. The converse is also true. If there is no joint probability distribution, then there is no non-contextual local hidden variables model. Starting from the observation that entangled quantum states, in the absence of any stabilizing fields, will decay under the influence of decoherence, we investigate the decay of a GHZ state under the influence of decoherence in a Markovian Master equation model. Using necessary and sufficient conditions for the existence of a joint probability distribution derived by de Barros and Suppes we then show that a joint probability distribution emerges after about 20% of the half time of the decay. Interestingly, at this time the system is still highly entangled, although a classical model can account for the correlations in it. Next, we study the physics before the emergence of a joint distribution. It turns out that the correlations of Bell states and GHZ states can be accounted for in terms of upper probability distributions, which are well known from the theory of uncertain reasoning. We will show that upper probabilities are also useful in quantum theory and explicitly construct upper distributions for the cases at hand. This talk is based on joint work with Patrick Suppes (Stanford).