AGPhil 5: Rods, Clocks, Space and Energy in General Relativity

Time: Wednesday 15:00–17:30 Location: A 060

Invited Talk AGPhil 5.1 Wed 15:00 A 060

"What is truth?" Einstein on Rods and Clocks in Relativity Theory — •Marco Giovanelli — FORUM SCIENTIARUM Doblerstraße 33 72074 Tübingen

The talk offers a historical overview of Einstein's vacillating attitude towards the role, indispensable or provisional, that rods and clocks play in both special and general relativity. The talk will document the context in which Einstein, at the beginning of 1917, first expressed concerns about the use of complicated material systems as measuring devices. It will consider the circumstances in which, in the 1920s, he felt the urgency to articulate his point of view in public writings, outlining a two-stage epistemological strategy, to which he remained faithful until the end of his life.

In particular it will be shown how Einstein expressed early on the conviction that in relativity theory one seems to be entitled to expect an explanation of how the measuring instruments work, without calling on other branches of physics. However, he was aware of the fact that this epistemological requirement calls into question the very relationship between a theory and the material devices that serve to verify it. Thus, Einstein's plea for a dynamical explanation of rods and clocks should be understood against the background of a truly philosophical question, which - as Einstein himself put it - is nothing but "Pilate's famous question: 'What is truth?'

AGPhil 5.2 Wed 15:45 A 060

The Problem of Space — •Joshua Eisenthal — University of Pittsburgh, Pittsburgh, Pennsylvania, USA

I define the Problem of Space as the problem of delimiting the range of candidate physical geometries, i.e. candidate geometrical descriptions of physical space. I briefly review the nineteenth century approach to this problem, arriving at the so-called "classical solution". This solution centered around the claim, advanced in particular by Helmholtz and Poincaré, that candidate physical geometries were just those structures which could represent the free mobility of rigid bodies. As noted originally by Riemann, then argued for by Helmholtz and proved rigorously by Lie, congruence relations which can represent such free mobility exist only in geometries of constant curvature. Both Poincaré and Helmholtz regarded this fact as pivotal in delimiting the range of candidate physical geometries, and thus solving the Problem of Space.

However, I then review how this view was fatally undermined by the development of General Relativity. I thus turn to explore the twentieth century solution to the Problem of Space advanced by Hermann Weyl. I conclude by reflecting on the significance of this discussion for a relatively recent dispute regarding the status of the metric field in General Relativity. I suggest that this dispute has arisen partially due to a failure to properly appreciate the insights made available by the kind of analysis of geometrical concepts exemplified by Weyl's work. More generally, I argue that the nuances of Weyl's view demonstrate the importance of engaging with the Problem of Space in interpreting General Relativity today.

AGPhil 5.3 Wed 16:15 A 060

Gravitational energy in general relativity — •James Read — Merton College, University of Oxford, OX1 4JD, UK

Recently, various authors have argued both for and against the proposition that the gravitational field described in General Relativity (GR) possesses "genuine" energy. I approach this debate systematically, by (1) presenting the various energy-momentum conservation laws in the theory (both local and global on the one hand, and for either matter energy or matter-plus-gravitational energy via a stress-energy pseudotensor on the other); (2) providing general philosophical principles according to which one can isolate the fundamental form that conservation laws in GR should take (contra much of the literature, this form is not that of an integral conservation law); and (3) using these criteria to identify the energy-momentum conservation laws in GR of greatest significance, and in turn to establish whether gravitational energy really does exist in GR. On (3), I find that, following conservative functionalist principles, genuine gravitational energy does exist in GR, but only in a restricted sense, when certain physical conditions apply. In addition, I argue that one can be a realist about gravitational energy even if one is a relationist about spacetime ontology, as adopting the latter position does not alter the fact that GR contains well-defined quantities which play the functional role of gravitational energy.

15 min. break.

AGPhil 5.4 Wed 17:00 A 060

Operationalization of relativistic energy-momentum — •Bruno Hartmann — Perimeter Institute, Waterloo, Canada — Humboldt Universitaet, Berlin

We present a novel approach to the foundation of physical theory, which begins with interrogations on practical measurements. Last time such approach had been successfully considered was by Einstein for the foundation of relativistic Kinematics. For the (so far unresolved) foundation problem of Dynamics we start from Hermann von Helmholtz analysis of basic measurements, as in known, very old procedure of length measurements by repeated placement of unit sticks one after the other.

We begin from definitions, which have a practical dimension. We introduce the measure of energy and momentum by pre-theoretic comparison (known from work experience): "more impact potential" (momentum) - if in a collision one object overruns the other - and "more effect potential" (energy) - if the kinetic effect of one source exceeds the effect of the other. With our calorimeter model (built by coupling congruent standard interactions of irrelevant inner structure) we can express their value also numerically (how many times more). We uncover the origin of true physical quantities of energy, momentum and inertial mass. From simple measurement-methodical principles - without mathematical presuppositions - we derive all fundamental equations of relativistic Dynamics. By genetic explanation of basic measures out of physical operations one can address and understand consequences and limitations of its mathematical formalism.