MP 11: Thermodynamics and fundamental aspects of field theory

Time: Thursday 16:35–18:15 Location: MP-H6

MP 11.1 Thu 16:35 MP-H6

Relation between the Cartesian multipole expansion and the spherical harmonic expansion — •Nils Walter Schween and Brian Reville — Max-Planck-Institut für Kernphysik, Saupfercheckweg 1, Heidelberg 69117, Germany

The multipole expansion, which is, for example, used to approximate an electrostatic potential (or a gravitational potential), has two equivalent forms. First, it is a Taylor expansion, i.e.

$$4\pi\epsilon_0\phi(\mathbf{r}) = \int \frac{\rho(\mathbf{r}')}{|\mathbf{r}-\mathbf{r}'|}\,\mathrm{d}r'^3 = \sum_{l=0}^{\infty}\frac{1}{l!}\frac{r^{i_1}\cdots r^{i_l}\mathbf{Q}_{i_1\cdots i_l}}{r^{2l+1}}\,.$$

Note the Einstein summation convention. Secondly, it is a spherical harmonic expansion, i.e.

$$4\pi\epsilon_0\phi(\mathbf{r}) = \sum_{l=0}^{\infty}\sum_{m=-l}^{l}\frac{4\pi}{2l+1}q_l^m\frac{r^l Y_l^m(\theta,\varphi)}{r^{2l+1}}\,.$$

We show that the relation between these two expansions can be formalised as a series of basis transformations of spaces of homogeneous polynomials of increasing degree l. These basis transformations allow us to derive an algorithm to express the components of the multipole tensors, i.e. $\mathbf{Q}_{i_1\cdots i_l}$, as linear combinations of the spherical multipole moments q_l^m for an arbitrary degree l. Since the spherical multipole moments are

$$q_l^m := \int Y_l^{m*}(\theta,\varphi)r'^l\rho(\mathbf{r})\,\mathrm{d}r'^3\,,$$

this opens the opportunity to compute $\mathbf{Q}_{i_1\cdots i_l}$ solving the above integral instead of performing the derivatives and integrations needed to compute the multipole tensor components directly.

MP 11.2 Thu 16:55 MP-H6

On the unification of mechanics and thermodynamics — •Grit Kalies — HTW University of Applied Sciences, Dresden, Germany

Mechanics and thermodynamics (TD) are usually considered to be unified. This view is based on the work of Clausius and Boltzmann [1, 2], who attributed the behavior of complex systems to idealized moved material points. Nevertheless, mechanics and TD have been incompletely unified so far. They are taught separately, use different types of energy, namely the external and internal energy, and while the equations of mechanics, relativistic mechanics, and quantum mechanics are invariant under time reversal, those of TD are not.

Based on recent work [3-6], a unified formulation of mechanical and thermodynamic process equations is presented: The internal and external energies of an object are described in a unified manner. The equation of the ideal gas is derived in a simple way using process equations. Force, entropy, chemical potential, Gibbs free energy and other state variables are vividly interpreted at the fundamental level. The findings, consistent with experiment, enable a realistic and causal quantum physics and cosmology to be developed.

[1] R. Clausius, Pogg. Ann. 142 (1871) 433-461; [2] L. Boltzmann, Sitzungsber. kaiserl. Akad. Wiss. Wien 66 (1872) 275-370; [3] G. Kalies, Z. Phys. Chem. 234 (2020) 1567-1602; [4] G. Kalies, Z. Phys. Chem. 235 (2021) 849-874; [5] G. Kalies: Back to the roots: The concepts of force and energy, Z. Phys. Chem. (2021) 1-53; DOI: 10.1515/zpch-2021-3122;[6] G. Kalies: On the unification of mechanics and thermodynamics, submitted (2021).

MP 11.3 Thu 17:15 MP-H6

The fundamental role of the proper time parameter in general relativity and in quantum mechanics — •René Friedrich — Strasbourg

Special relativity provides time with a precise physical concept, splitting the absolute Newtonian time into two different time concepts, proper time and coordinate time: In a first step, time is generated by rest energy, in the form of the proper time parameter of a worldline of a particle, and in a second step, the worldline is observed, by measuring the corresponding coordinate time parameter of the observer. Conversely, from the observed coordinate time we may retrieve by calculation the underlying proper time of the worldline. Proper time is time before time dilation, and coordinate time is time after time dilation. This is why for fundamental, unresolved questions about time we should not refer to the coordinate time parameter of spacetime but to the more fundamental parameter of proper time.

MP 11.4 Thu 17:35 MP-H6

Electrodynamics and the Isoclinic Decomposition of SO(4) — •Alexander Unzicker — Pestalozzi-Gymnasium München

According to William Rowan Hamilton, quaternions are a 'fundamental building block of the physical universe'. By visualizing unit quaternions with the stereographic projection, it is shown that unit quaternions display many characteristic features of electrodynamics. The question as to the origin of this interaction thus might be approached with an alternative description of spacetime by means of quaternions.

MP 11.5 Thu 17:55 MP-H6

On Negative Mass, Dark Energy and Dark Matter — •Antoine A.J. van de Ven — Alumnus of Utrecht University, P.O. Box 19027, 3501 DA, Utrecht, The Netherlands

Back in 1957 Bondi published about negative mass in general relativity. In 2003 the author published a new formalism and redefinition of mass and energy in which antimatter has negative mass while its energy is still always positive and wrote 'It is predicted that antimatter has antigravitational properties and that antimatter is the dark energy in the universe'. In later presentations it was also further elaborated that this can also explain away dark matter without further assumptions. Antimatter with repulsive gravitational fields surrounding a galaxy will generate an extra inward gravitational force without needing dark matter. This was also presented at 'The Dark Universe Conference' in Heidelberg in 2011 and other places and has been used and cited by others. See the references in [1]. In this presentation an update will be given including an alternative formulation and interpretation of the Dirac equation with quaternions in which negative energies are avoided and in which it is derived that antimatter has negative mass in this formalism.

Reference:

[1] S. Thakur and S. Mukerji, "A Brief Study of the Universe," International Journal of Astronomy and Astrophysics, Vol. 3 No. 2, 2013, pp. 137-152. doi:10.4236/ijaa.2013.32016