Fritz-Haber-Institut der Max-Planck-Gesellschaft

Please join us at the

Symposium for Bretislav Friedrich

to celebrate Bretislav's 65th birthday – with science, music, and some good fare. The symposium will be held on Friday, April 12, 2019 in Harnack-Haus, Ihnestrasse 16-20, 14195 Berlin, and unfold as follows:

13:00 Welcome Coffee; Musikalischer Auftakt

13:30 Dudley R. Herschbach (Harvard University)

14:15 John M. Doyle (Harvard University)

15:00 Henrik Stapelfeldt (University of Aarhus)

15:45 Coffee Break

16:15 Mikhail Lemeshko (Institute of Science and Technology Austria)

17:00 Mary Jo Nye (Oregon State University)

18:00 Musikalischer Ausklang; Champaign Reception

19:00 Dinner with music and reminiscences

I hope you will be able to attend and look forward to seeing you at the symposium,

Gerard Meijer

For more information, please see https://indico.fhi-berlin.mpg.de/event/36/.

“Bringing Molecules to Attention”

Dudley Herschbach, Harvard University

Bretislav is fond of the title of this talk, crafted by him. It was a major theme in the superb Festschrift [1] celebrating his 60th birthday. There he presented an intriguing autobiography, with engaging vignettes about colleagues as well as synopses of his research, teaching, and historical scholarship. These are updated in his exemplary website [2], including an extensive array of his “favourite aphorisms related to Science.” During his Harvard era (1987-2003) Bretislav kept molecules and colleagues busy both in my chemistry lab and John Doyle’s physics lab. Here I will mention a few episodes and some later consequences. In 1990, Bretislav enjoyed making molecules behave like pendulums. Previously, to do that with electric fields was deemed not practical for molecules in a gas, tumbling like pinwheels. By now, pendular molecules have had key roles in countless experiments, rendered by means of electric or laser fields. A kindred episode dealt with molecular polarizability, previously disrespected as too puny, yet begat further varieties of pendular states. Some offer prospective qubits for quantum computation, others can serve as catalysts for chemical reactions. On arriving at Harvard, Bretislav took part in a Festschrift [3] for the centennial year of Otto Stern (1888-1969). Since then, Bretislav and colleagues have contributed many papers, books, and symposia enriching History of Science.

[1] Molecular Physics, **111**, 1631-1938 (2013).
[2] www.fhi-berlin.mpg.de/mp/friedrich/
[3] Zeitschrift für Physik D **10**, 109-392.

“The Road from Buffer-gas Cooling to Single Trapped Molecules”

John Doyle, Harvard University

Ultracold molecules are a promising platform for diverse scientific goals, ranging from quantum information and simulation to controlled chemistry and precision measurements of fundamental physics. The rich internal structure of molecules, including vibrations, rotations, and hyperfine interactions, provides many handles for exquisite control. However, the very same structural features that make

molecules so desirable to study also complicate the task of controlling them.
25 years ago at Harvard we started work to trap molecules and study their interactions. This was long before the idea of molecules as qbits had come onto the scene. We began with the simple idea that a very cold cryogenic gas could provide the dissipation to load molecules into a magnetic trap. This led to a series of experiments that included the first magnetic trapping of a molecule and study of collisional properties, in particular spin relaxation. We discovered that magnetic trapping was delicate and that only a few species of molecules would be amenable to our initial approach. This led us to separate the cooling mechanism from the trapping mechanism and gave birth to the buffer-gas beam. Later, this beam turned out to be ideally suited to the laser cooling of molecules, as done in several labs now, including our lab with CaF and SrOH.
Laser cooling and magneto-optical trapping of diatomic molecules from a buffer-gas beam has been realized. In our lab temperatures as low as a few μK have been achieved in long-lived, optically trapped samples of CaF. Photon cycling of these types of molecules allows for high fidelity detection of ultracold molecules and for increases in phase space density allowing for, e.g., the study of ultracold molecular collisions. In this talk, I will outline the path from the early days at Harvard to now a very large field of research on cold, trapped molecules including a path to ultracold polyatomic molecules. I will also present our latest results, which includes the trapping and high-fidelity readout of single molecules in optical tweezers.

“Laser-induced alignment and imaging of molecules embedded in helium nanodroplets”

Henrik Stapelfeldt, University of Aarhus

I will show how laser pulses can align molecules in helium nanodroplets and how the ability to place molecules in advantageous spatial orientations allows structural determination of molecular complexes. The talk will focus on the following topics:
(1) <u>Alignment of molecules with pulses much shorter than the molecular rotational periods.</u> The experimental results show rotational

dynamics that differs completely from that of isolated molecules [1]. Notably, pronounced oscillations in the time-dependent molecular alignment, with no counterpart in gas phase molecules, are observed. Angulon theory identifies the oscillations to originate from the unique rotational structure of molecules in He droplets [2].

(2) Alignment induced by pulses that are turned-on (quasi) adiabatically.

It will be shown how the 0.4 K temperature of the molecules inside the droplets enables unprecedented high degrees of alignment, in either one or three dimensions. The method applies to large, complex molecules and the alignment can be made field-free by rapidly switching off the alignment pulse [3].

(3) Femtosecond-laser-induced Coulomb explosion imaging of the structure of molecular dimers and trimers created inside He droplets.

Results for both small linear molecules, including CS_2 [4] and OCS, and the larger molecule tetracene, are presented. Perspectives for time-resolved imaging of bimolecular reactions and interactions are discussed.

[1] B. Shepperson, A. A. Søndergaard, L. Christiansen, J. Kaczmarczyk, R. E. Zillich, M. Lemeshko, and H. Stapelfeldt, Phys. Rev. Lett. **118**, 203203 (2017).

[2] I. N. Cherepanov, G. Bighin, L. Christiansen, A. V. Jørgensen, R. Schmidt, H. Stapelfeldt, and M. Lemeshko, in preparation (2019).

[3] A. S. Chatterley, C. Schouder, L. Christiansen, B. Shepperson, M. H. Rasmussen, Henrik Stapelfeldt, Nat. Comm. **10**, 133 (2019).

[4] J. D. Pickering, B. Shepperson, B. A. K. Hubschmann, F. Thorning and H. Stapelfeldt, Phys. Rev. Lett. **120**, 1121321 (2018).

“The angulon quasiparticle: from molecules in superfluids to ultrafast magnetism”

Mikhail Lemeshko, Istitute of Science and Technology Austria

Recently we have predicted a new quasiparticle - the angulon - which is formed when a quantum impurity (such as an electron, atom, or molecule) exchanges its orbital angular momentum with a many-particle environment (such as lattice phonons or a Fermi sea) [1,2]. Soon thereafter we obtained strong evidence that angulons are

formed in experiments on molecules trapped inside superfluid helium nanodroplets [3]. The angulon theory thereby provided a simple explanation for experimental data accumulated during the last two decades. Moreover, casting the many-particle problem in terms of angulons amounts to a drastic simplification and allows to tackle previously intractable problems related to quantum dynamics [4].
In this presentation we will introduce the angulon concept and discuss novel physical phenomena [1,5,6] arising from the angular momentum exchange in quantum many-particle systems. We will describe the applications of angulons to modern experiments on quantum impurities and on non-equilibrium magnetism [7].

[1] R. Schmidt, M. Lemeshko, Phys. Rev. Lett. 114, 203001 (2015).
[2] R. Schmidt, M. Lemeshko, Phys. Rev. X 6, 011012 (2016).
[3] M. Lemeshko, Phys. Rev. Lett., 118, 095301 (2017); Viewpoint: Physics 10, 20 (2017).
[4] B. Shepperson, A. A. Sondergaard, L. Christiansen, J. Kaczmarczyk, R. E. Zillich, M. Lemeshko, H. Stapelfeldt, Phys. Rev. Lett. 118, 203203 (2017).
[5] E. Yakaboylu, M. Lemeshko, Phys. Rev. Lett. 118, 085302 (2017).
[6] E. Yakaboylu, A. Deuchert, M. Lemeshko, Phys. Rev. Lett. 119, 235301 (2017).
[7] J.H. Mentink, M.I. Katsnelson, M. Lemeshko, arXiv:1802.01638 (2018).

“Bretislav Friedrich and History of Science”

Mary Jo Nye, Oregon State University

Bretislav Friedrich’s scientific work is complemented by historical research and studies that he began publishing in 1996. This talk focuses on some of the leading themes in his historical work. These themes include biographical essays and articles on Otto Stern, Fritz Haber, Otto Sackur, Michael Polanyi, and Clara Immerwahr, along with histories of physical chemistry, the Fritz Haber Institute, and the development of chemical warfare. As in his scientific research, much of the historical work is collaborative, reconstructing important scientific achievements and historical contexts, while often also addressing issues of scientific ethics and responsibility.

Prof. Ronith Mues

Ihren ersten Harfenunterricht erhielt Ronith Mues im Alter von fünf Jahren von ihrer Mutter Ragnhild Kopp, Dozentin i.R. am Richard-Strauss-Konservatorium München. Ihr Studium absolvierte sie an der Hochschule für Musik „Hanns Eisler" Berlin und machte anschließend ihr Konzertexamen an der Hochschule für Musik und Theater Hamburg. Sie hatte schon in den Jahren vor ihrem Studium viele erste Preise, unter anderem beim Concours International de Harpe A.S.T.H. in Lyon, beim Wettbewerb der Deutschen Harfenvereinigung sowie beim Internat. Instrumentalwettbewerb „Rovere d´Oro" gewonnen.

Seit August 2007 ist Ronith Mues Soloharfenistin des Konzerthausorchesters Berlin. Bereits über zehn Jahre existiert das aus den Solisten ihres Orchesters bestehende „Horenstein Ensemble", welches mit seinen CD Einspielungen stets einzigartige Projekte verwirklicht: LP/CD „Tempelhof" (ACOUSENCE records, 2011); CD „Lost Generation" (ACOUSENCE records, 2015); CD „Dichterliebe" (recomposed und initiiert von dem Komponisten Christian Jost, DEUTSCHE GRAMMOPHON, erscheint am 12. April 2019).

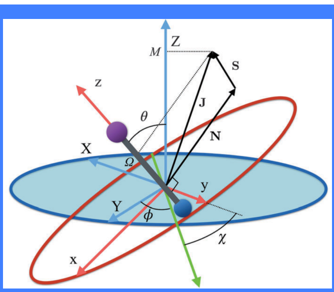
Als Solistin sowie mit ihrem Ensemble konzertiert Ronith Mues national sowie international unter anderem bei den Ludwigsburger Schlossfestspielen, dem Rheingau Musikfestival, beim Lucerne Festival und mit dem Konzerthausorchester Berlin. Tourneen führte sie neben Europa unter anderem nach Südamerika, Russland, Japan sowie Süd- als auch Nordkorea.

Neben ihrer Konzerttätigkeit widmet sich Ronith Mues intensiv dem musikalischen Nachwuchs, gibt Meisterkurse und ist als Dozentin für Harfe beim Bundesjugendorchester tätig. Seit Oktober 2015 lehrt sie als Professorin für Harfe an der Staatlichen Hochschule für Musik und darstellende Kunst Mannheim.

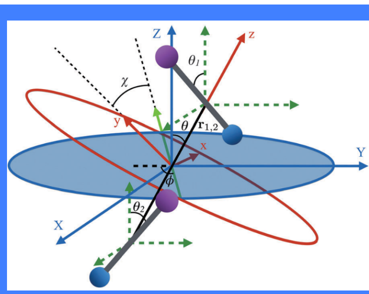
Musikalische Umrahmung des "Symposiums für Bretislav Friedrich" am 12.4.2019 im Harnack-Haus:
1. Die Moldau von Bedrich Smetana; 2. Prelude in C von Sergej Prokofjew; 3. Adagio aus der Sonate für Harfe von Carl Ph. Em. Bach; 4. Variationen über ein Thema aus einer Oper von Mehul von Louis Spohr.

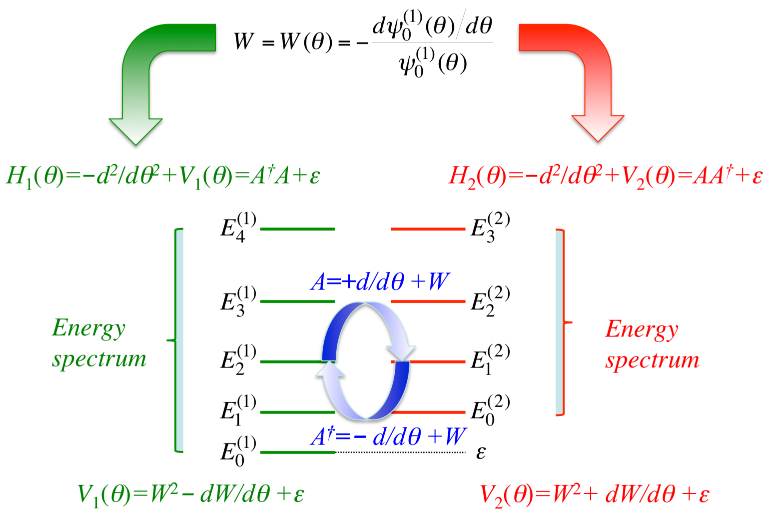
Ronith Mues spielt eine Harfe der Firma Horngacher.

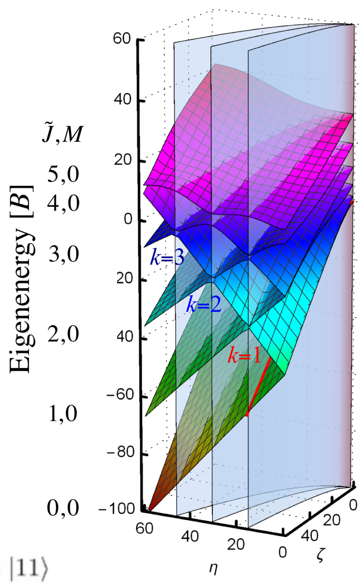
Notes

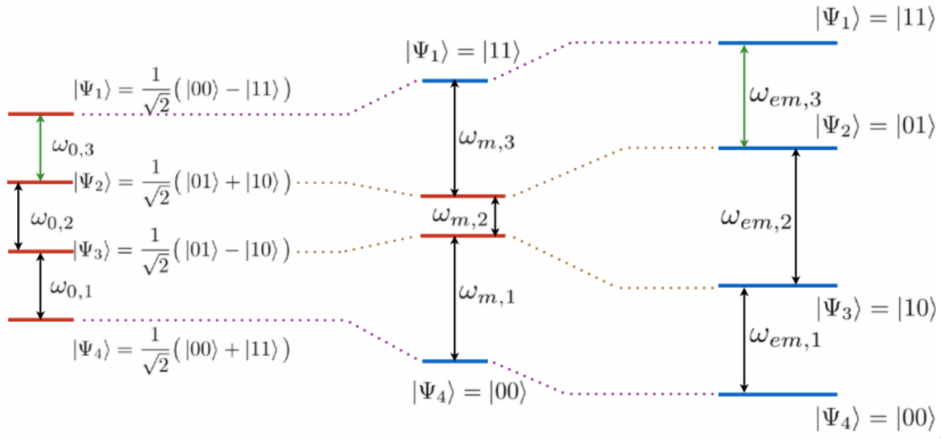


Interactions of molecules with and in fields









History of Science