Enabling Scientific Impact

selected customer publications

attoCFM & attoDRY

Controlling the polarization eigenstate of a quantum dot qxciton with light	T. Belhadj et al.	Phys. Rev. Lett. **103** 086601 (2009)
Robust optical emission polarization in MoS_2 monolayers through selective valley excitation	G. Sallen et al.	Phys. Rev. B **86** 081301 (2012)
Bright solid-state sources of indistinguishable single photons	O. Gazzano et al.	Nat. Commun. **4** 1425 (2013)
Spin-orbit engineering in transition metal dichalcogenide alloy monolayers	G. Wang et al.	Nat. Commun. **6** 10110 (2015)
A quantum phase switch between a single solid-sta te spin and a photon	S. Sun et al.	Nat. Nanotechnol. **11** 539 (2016)
Multi-photon boson-sampling machines beating early classical computers	H. Wang et al.	arXiv:1612.06956 (2016)
Near-transform-limited single photons from an efficient solid-state quantum emitter	H. Wang et al.	Phys. Rev. Lett. **116** 213601 (2016)
On-demand single photons with high extraction efficiency and near-unity indistinguishability from a resonantly driven quantum dot in a micropillar	X. Ding et al.	Phys. Rev. Lett. **116** 020401 (2016)
Synthesis of highly anisotropic semiconducting GaTe nanomaterials and emerging properties enabled by epitaxy	H. Cai et al.	Adv. Mater. **29** 1605551 (2016)
Valley- and spin-polarized Landau levels in monolayer WSe_2	Z. Wang et al.	Nat. Nanotechnol. **12** 144 (2016)
Combining in-situ lithography with 3D printed solid immersion lenses for single quantum dot spectroscopy	M. Sartison et al.	Sci. Rep. **7** 39916 (2017)
Contamination of polymethylmethacrylate by organic quantum emitters	A. Neumann et al.	arXiv:1706.08341 (2017)
Enabling valley selective exciton scattering in monolayer WSe_2 through upconversion	M. Manca et al.	Nat. Commun. **8** 14927 (2017)
Excitonic linewidth approaching the homogeneous limit in MoS_2 based van der Waals heterostructures: accessing spin-valley dynamics	F. Cadiz et al.	Phys. Rev. X **7** 021026 (2017)
Large-area superconducting nanowire single-photon detector with double-stage avalanche structure	R. Cheng et al.	IEEE Trans. on Appl. Supercond. **27** 1 (2017)
Opto-valleytronic imaging of atomically thin semiconductors	A. Neumann et al.	Nat. Nanotechnol. **12** 329 (2017)
Probing the spin-polarized electronic band structure in monolayer Transition Metal Dichalcogenides by optical spectroscopy	Z. Wang et al.	Nano Lett. **17** 740 (2017)
Scalable boson sampling with a single-photon device	Y. He et al.	Phys. Rev. Lett. **118** 190501 (2017)
Strongly interaction-enhanced valley magnetic response in monolayer WSe_2	Z. Wang et al.	arXiv:1603.04127 (2017)

attoRAMAN

Raman spectroscopy of Carbon nanostructures in strong magnetic field	M. Kalbac et al.	Int. J. Chem., Nuc., Met. Mat. Eng. **8** 1145 (2014)
Evolution of temperature-induced strain and doping of double-layer graphene: An in situ Raman spectral mapping study	T. G. A. Verhagen et al.	Phys. stat. solidi (b) **252** 2401 (2015)
Low B field magneto-phonon resonances in single-layer and bilayer graphene	C. Neumann et al.	Nano Lett. **15** 1547 (2015)
Temperature-induced strain and doping in monolayer and bilayer isotopically labeled graphene	T. G. A. Verhagen et al.	Phys. Rev. B **92** 125437 (2015)
Magnetic modes in rare earth perovskites: A magnetic-field-dependent inelastic light scattering study	S. Saha et al.	Sci. Rep. **6** 36859 (2016)
Magneto-optical study of defect induced sharp photoluminescence in $LaAlO_3$ and $SrTiO_3$	S. Sarkar et al.	Sci. Rep. **6** 33145 (2016)
Temperature dependence of the 2D' mode of an isotopically labelled graphene double layer	T. Verhagen et al.	phys. stat. solidi (b) **253** 2342 (2016)

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Variable temperature & high magnetic fields

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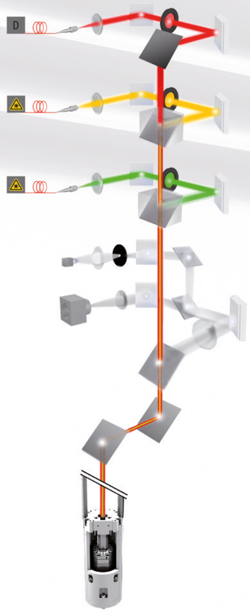
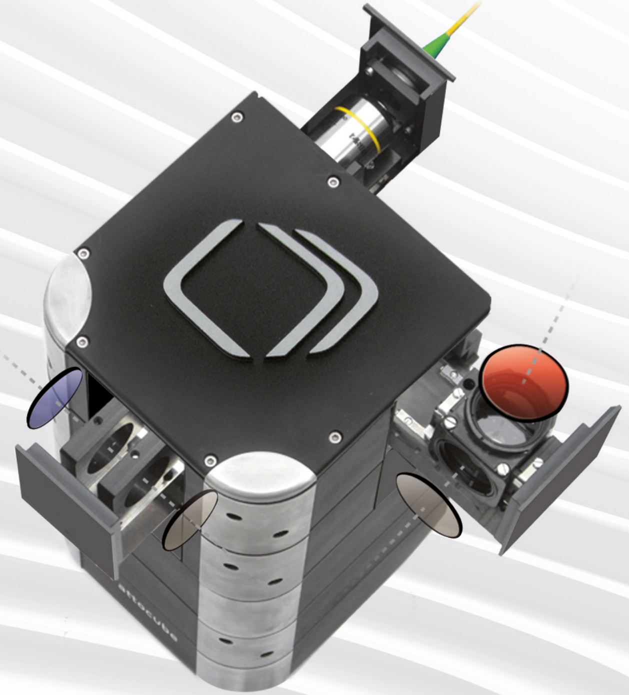




attoCFM & attoRAMAN

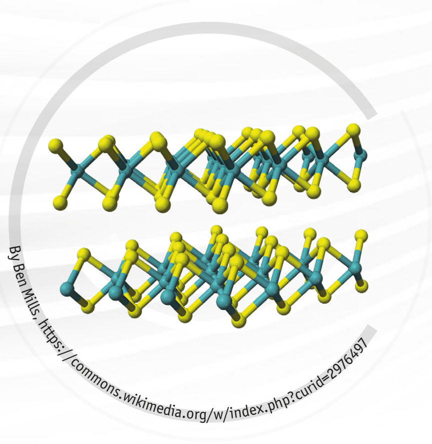
low temperature confocal microscopy

CRYOGENIC INSTRUMENTS

cool tools for cold science

attoCFM & attoRAMAN

low temperature confocal microscopy



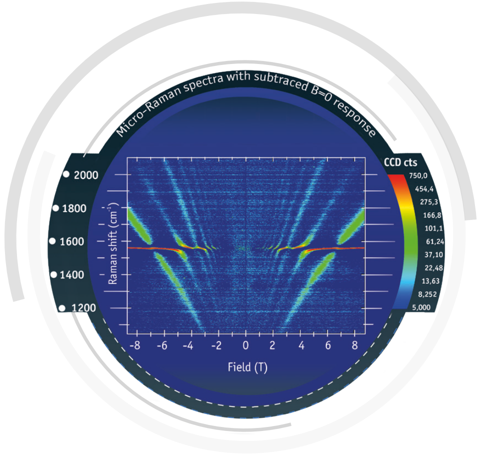
2D materials: Dichalcogenides & Graphene

This class of 2D materials offers a rich variety of physics useful for fields such as optoelectronics. It has been in the center of quantum optics research over 10 years now since the advent of graphene. Typically these materials are characterized and further studied at low temperatures, to minimizes thermal broadening of the photoluminescence spectra, and often under high magnetic fields in Faraday & Voigt geometry. The attoCFM I offers an ideal platfrom for magneto-optical studies in conjunction with the automated attoDRY2100 cryostat.

µ-Raman spectroscopy

Graphene has seen tremendous interest in solid state physics and Raman spectroscopy was one of the central techniques to characterize its properties from the start. The attoRAMAN offers the unique possibility to extend such studies not only over a broad temperature range between 1.65 .. 300 K, but also to high magnetic fields. In cooperation with the group of M. Potemski, we recorded magneto-Raman spectra at 4 K on an exfoliated single crystal of natural graphite with unprecedented spatial resolution (approx. 0.5 µm), while sweeping the magnetic field from -9 T to +9 T, showing the crossing of the E2g phonon energy with the electron-hole separation between the valence and conduction Landau levels (-N,+M) of the Dirac cone.

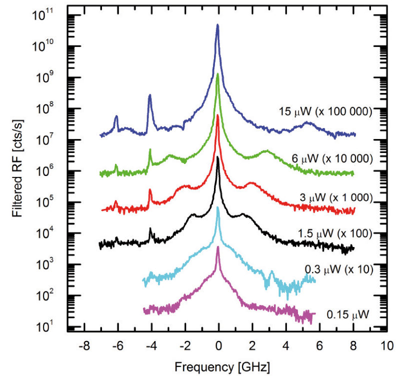
(attocube application labs, 2011; work in cooperation with C. Faugeras, P. Kossacki, and M. Potemski, LNCM I - Grenoble, CNRS_UJF_UPS_INSA France)



Fields of Applications

low temperature confocal microscopy

Quantum dot photoluminescence



One prominent yet difficult example of spectroscopy of semiconductor quantum dots (QDs) is the resonant optical laser excitation of single photon emitters. This yields additional information about the emitters than the more ubiquitous non-resonant excitation. The attoCFM I can be upgraded with a resonant fluorescence package, that permits alignment free switching between off resonant PL measurements and RF thanks to our cryogenic apochromatic objectives. The integrated high precision rotators enable extinction ratios of 107 [1], just a factor 10 away from the world record in research labs [2], while allowing an unprecedented flexibility of use.

[1] attocube AppNote M45 - attoCFM I - Resonant spectroscopy on a single quantum dot
[2] A.V. Kuhlmann et al., Review of Scientific Instruments 84, 073905 (2013).

Photocurrent measurements

Using our sample holders with electrical contacts, photocurrent measurements in variable field and temperature are easily possible.
For example, the group of P. Sutter has used our fiber-based attoCFM II for spatially resolved photocurrent measurements on a graphene field-effect device in the QHE regime. They studied the distribution of Landau levels and its relation with macroscopic transport characteristics [1].
The exceptional stability and the ease of use of the attoCFM microscope greatly facilitated these measurements and allowed for measuring working devices in magnetic fields from -9 to +9 T.

[1] G. Nazin, Y. Zhang, L. Zhang, E. Sutter, P. Sutter, Nature Physics 6, 870–874 (2010)