

Facilities and Resources **Note this is the general summary of the facilities and resources available for Physics. Each P.I. may use this format as a template to reference as his/her facilities & resources section. It is recommended that each PI modify the content, font, and formatting as needed to include your preferences in order to meet your specific project needs and sponsor specifications**

The Department of Physics within the College of Natural and Mathematical Sciences at the University of Maryland Baltimore County. Research in the UMBC Physics Department is centered in 4 main areas: astrophysics, atmospheric physics, condensed matter physics, and quantum optics and quantum information science. Our research is primarily conducted in the 78,000 square-foot Physics Building (built in 1999), which houses numerous laboratories, researcher office space, computational facilities, and shared major facilities including the nanoimaging facility, Physics Machine Shop, observational telescope, and individual labs among the 4 areas of Physics. Other campus resources include machine shops with CNC capabilities, a glassware facility, electronics shops, cold rooms, ultracentrifuges, and clean-room facilities.

IMAGING FACILITIES

Nanolmaging Facility. Relevant instrumentation includes (1) an FEI Nova Nanoscan 450 scanning-electron microscope, with single-nanometer-scale imaging resolution and spatially resolved elemental analysis; and (2) a Veeco Dimension 3100 atomic force microscope. The Nanolmaging Facility is located in the Physics building.

Keith R. Porter Imaging Facility

Provides shared microscopy resources for biological and materials science research. Equipment and services are available to all faculty and staff at UMBC, as well as the surrounding academic and industrial communities. KPIF staff support all aspects of imaging, including protocol development, sample preparation, equipment training and image processing. Dedicated full time staff are available for consultation and can provide training for researchers to use the instruments. All instruments and services are available to the PI for a fee. These instruments are located in several buildings on campus, including the Biological Sciences building, the ILSB, and Physics building. Instruments available include a Zeiss LSM 910 confocal laser scanning microscope with AI sample finder, Zeiss LSM 900 confocal laser scanning microscope with Airyscan and incubation chamber, a Zeiss Axio Zoom.V16 stereomicroscope, a Zeiss Axio Observer 7 fluorescence microscope with Apotome2, a Leica M205 FA fluorescence stereomicroscope and a Hitachi HT7800 transmission electron microscope. There is also a dedicated computer workstation for fluorescence microscopy image processing including Imaris (Bitplane) for 3D reconstruction and Huygens (SVI) for image restoration. Additional instruments include a FEI Nova NanoSEM 450 scanning electron microscope with energy-dispersive X-ray spectroscopy (EDS) and electron backscatter diffraction (EBSD) detectors, and a Bruker Dimension Edge atomic force microscope. Sample preparation equipment for electron microscopy includes a PELCO easiGlow glow discharge cleaning system and a Cressington 108 Manual Sputter and Carbon Coater.

Molecular Characterization and Analysis Complex. Relevant instrumentation includes (1) FTIR, UV-Vis, and fluorescence spectroscopy; (2) thermogravimetric analysis; (3) ICR and TOF mass spectroscopy, including ICP, ESI, APCI, and MALDI sources; (4) HPLC; and (5) NMR.

LABORATORIES

The PI's laboratory is XXXX square feet and is housed in the XXXX. The lab space consists of XXXX rooms. A total of XXXX benches are available for research personnel. [Describe specifics in detail- equipment present, use of space, etc]

Atmospheric Physics:

Laboratory for atmospheric studies and particle light interaction (LASPLI)- This lab is led by Dr. Roch-Lima. Her laboratory counts with an infrastructure that includes an experimental setup for controlled resuspension of atmospheric particles, an automatic sonic sieve for particle size separation, high precision scales for determination of mass, and a gas pycnometer Ultrapyc 5000 Micro for grain volume measurements and density derivation. In addition, LASPLI has a dedicated Power Edge T440 Tower Server, with 16TB storage capacity. The laboratory is being designed by Dr. Rocha Lima and is currently supported with start-up resources from UMBC's Physics department and Provost.

Astrophysics:

Condensed Matter Physics:

Simulation, Theory and Engineering of Advanced Materials Laboratory (STEAM Lab)- Dr. Ataca's lab focuses on computational research and his computer cluster which consists of the following:

- 29 nodes (1160 cores in total). Each node features two Intel Xeon 6230-20 core CPUs with 384 GB of memory and SSD storage.
- The head node is consisting of 2 storage solutions: (i) 50 TB Raid 5 system for on-going simulations, (ii) 400 TB Raid 5 system for back-up of (i), long term storage and webserver for outside access.
- Cluster is stored in climate-controlled room and the room has 2 external AC units for redundancy.
- The head node and storage server of the cluster is backed-up by Uninterrupted Power Supply (UPS) units for safely powering the system off for extended power outage scenarios.
- The system administration is done by Co-I's group.
- There is no time or number of node/core limit in this cluster.

Material Physics Lab- Dr. Gougousi's two labs occupy approximately 1000 ft² in the Physics building at UMBC. One thermal Atomic Layer Deposition (ALD) reactor equipped with a Quartz crystal microbalance (QCM), a supercritical carbon dioxide thin film deposition system, and a Physical Vapor Deposition (PVD) tool is currently operational. All the required hardware to

implement a plasma-enhanced ALD process is also available including an RF power supply and matching network and a quartz tube. A miniature ALD reactor based on a flow ATR-FTIR cell is also operational and allows direct monitoring on the surface during each ALD process half step. Facilities in the PIs' labs available for thin film characterization include Fourier Transform Infrared Spectroscopy (Thermo Nicolet 4700), Spectroscopic ellipsometry (Wollam alpha-SE 380-900nm), step profilometry (Tencor ASIQ), a probe station with a picoammeter (Keithley 6487) and an LCR (Agilent 4284A) for I-V and C-V measurements, an ISCO 260D syringe pump, an infrared mini lamp annealer (ULVAC MILA-3000) and an optical Microscope equipped with a digital camera (Nikon Optiphot-100). The labs are equipped with a fume hood and include safety monitoring systems for fire. Several state-of-the-art networked computers are available for data acquisition and reduction.

Diederich Lab: This lab focuses on applying ultrafast pulses to measure and manipulate the complex physics accessible in quantum materials. This lab consists of the following:

- 1 kHz amplified titanium:sapphire laser system with 25 femtosecond, 10 mJ pulses.
 - Optical parametric amplifier for tuning these pulses over a wavelength range of ~300 nm to ~3,000 nm
- GRENOUILLE pulse diagnostic system for characterizing temporal pulse characteristics and phase
- Optical liquid helium cryostat, base temperature ~10 kelvin
- Optics and electronics for generating and measuring terahertz energy laser pulses
- Many lock in amplifiers, oscilloscopes, and other signal recovery and measurement units

New equipment coming soon to the lab include the following:

- Multidimensional coherent spectrometer for measuring the ultrafast coherent dynamics of systems
- Optical liquid helium cryostat with integrated 1,1,1 T superconducting vector magnet
- Autocorrelators for measuring pulse duration at various points in the experiments
- Pulse compressors for achieving 50 fs pulses at the sample
- FPGA based signal recovery units that can function as oscilloscopes, lock-in amplifiers, boxcar averagers, and more
- A 1024x1024 pixel camera with a lock-in amplifier circuit on each pixel for performing widefield ultrafast imaging
- Adaptive optics for real time control over structured light excitations
- Plenty of Optics

Quantum Optics & Quantum Information-

Laboratory for Optical Studies of Nanoscale Physics - Dr. Pelton has a state-of-the-art research laboratory with two large optical tables, an 8-foot chemical fume hood, and a suite of standard laboratory equipment. The major equipment in the laboratory consists of the following:

- An ultrafast transient-absorption spectroscopy system. A Spectra-Physics Spitfire Ace Ti:sapphire amplifier system, seeded by a Millennium-pumped Tsunami oscillator, generates 100-fs pulses at 2 kHz. Part of the power from these pulses is used to generate tunable pump pulses using a Topas optical parametric amplifier, equipped with a NirUVis frequency-doubling and frequency-mixing system. The remaining part of the amplifier output is used to generate broadband probe pulses. The transient spectra are collected using an Ultrafast Systems Helios ultrafast spectroscopy system. The system can measure frequency-resolved transient-absorption data in the visible and near-infrared spectral regions over time scales from 100 fs up to 3 ns.
- A custom-built single-particle microscopy and spectroscopy system. Far-field microscopy is used to collect photoluminescence and dark-field scattering from individual nanoparticles or molecules. The system is equipped with a closed-loop nanopositioning stage, and has two picosecond pulsed / CW diode lasers as well as a halogen lamp as excitation sources. Single-particle spectra can be measured using a Princeton Instruments SpectraPro grating spectrometer equipped with a PhotonMax CCD array detector. Time-resolved emission kinetics can be measured through time-correlated single-photon counting, using PDM single-photon avalanche diodes from MPD, and PicoHarp 300 electronics from PicoQuant.

Quantum Optics Laboratory- Dr. Yanhua Shi lab is the leading laboratories in the field of quantum optics that attempts to probe the foundation of quantum theory. Their pioneering research on multi-photon entanglement, multi-photon interferometry, quantum imaging, and optical tests of foundations of quantum theory has attracted a great deal of worldwide attention.

Pittman's Laboratory- Dr. Todd Pittman's lab consists of the following relevant equipment to support experimental research on quantum computing with single photon qubits, quantum entanglement, and ultralow-power nonlinear optics:

Coherent "Mira 900" mode-locked Ti-Sapph. laser pumped by a 5 Watt "Verdi" solid-state laser. This system produces wavelength tunable (700 – 900 nm) pulse trains at a repetition rate of 76 MHz with pulse widths of ~150 fs.

PHYSICS DEPT.

- Menlo Systems "C-Fiber 780" mode-locked fiber laser with an integrated frequency-doubling unit and dual 780 nm and 1560 nm outputs. The pulse train repetition rate is 100 MHz with pulse widths of ~100 fs.
- Numerous 405 nm and 780 nm CW fiber-coupled diode lasers for auxiliary PDC pumping and alignment.
- Numerous frequency doubling and SPDC crystals.
- A total of 12 commercial free-space and fiber-coupled SPCM's (single-photon counting modules) for single-photon detection at both ~800 nm and ~1550 nm.
- High-speed EO modulator (Pockels cell) drivers, and Pockels cell heads.
- Custom high-precision low-loss optical delay lines used to adjust the relative delay between PDC photons.
- LabView-based integrated computer control and data acquisition systems.
- TTL-based electronics for switching and feed-forward control applications.

- Sub-micron high-precision 3-axis translation units for accurate fiber-launching.
- High-Speed coincidence counting electronics (both NIM format, and commercial units) used for photon counting.
- Large quantities of optics, mounts, filters, fiber-spools, test fibers, etc.
- Fiber optic tools such as cleavers, polarization controllers, and a fusion splicer.
- Fiber optic components including beamsplitters, polarizing beamsplitters, circulators, variable couplers, etc.
- High-speed oscilloscopes, wavelength meters, and general photonics tools.
- Ultra-high vacuum systems for Rb and Xe spectroscopy experiments.
- RF discharge systems for Xe experiments.
- 5 New-Focus and Toptica narrow-band tunable diode lasers covering the 776-780 nm and 823-853 nm wavelengths of interest for Rb and Xe experiments.
- Numerous low-light level silicon photo-diodes used for low-noise nanowatt, picowatt, and femtowatt power-level detection.

MACHINE SHOP

COMPUTER RESOURCES

The UMBC High Performance Computing Facility (HPCF):

The UMBC High Performance Computing Facility (HPCF) is the community-based, interdisciplinary core facility for scientific computing and research on parallel algorithms at UMBC. The facility is open to UMBC researchers at no charge. System administration is provided by the UMBC Division of Information Technology, and users have access to full-time consulting support. The computing capabilities include over 170 CPU nodes, a GPU cluster with 19 nodes, and 8-node Big Data cluster. System administration is provided by the UMBC Division of Information Technology. HPCF is the community-based, interdisciplinary core facility for scientific computing and research on parallel algorithms at UMBC. HPCF currently consists of two machines, taki and ada, and both comprise of several types of nodes. The current machine in HPCF contains over 170 CPU nodes freely accessible to any UMBC faculty and research personnel (graduate, undergraduate, postdocs).

The CPU cluster consists of 18 compute nodes with two 24-core Intel Cascade Lake CPUs and 196 GB of memory each, 42 compute nodes with two 18-core Intel Skylake CPUs and 384 GB of memory each, and 49 compute nodes with two 8-core Intel Ivy Bridge CPUs and 64 GB of memory each. This cluster also includes 4 nodes in a develop partition and one interactive node.

The taki GPU cluster contains one node with four NVIDIA Tesla V100 GPUs connected by NVLink and 18 hybrid CPU/GPU nodes with two NVIDIA K20 GPUs.

The Big Data cluster consists of 8 nodes in taki that are equipped with two 18-core Intel Skylake CPUs, 384 GB of memory, and 48 TB disk space distributed across 12 hard drives each.

The ada GPU cluster is comprised of 13 nodes which each have two 24-core Intel Cascade Lake CPUs and 384 GB of memory. Four of these nodes have eight 2080 Ti GPUs; seven of these

nodes have eight RTX 6000 GPUs; and two of these nodes have eight RTX 8000 GPUs with an extra 384 GB of memory each. This brings the total number of GPUs to 104.

The nodes are connected to each other by EDR (extended data rate) InfiniBand interconnect. All nodes of both machines are connected to the same central storage of more than 750 TB.

LIBRARY RESOURCES

The Albin O. Kuhn Library & Gallery promotes intellectual growth and creativity by developing high quality collections, facilitating access to information resources, and furthering innovative teaching and learning. The library includes seven floors of physical media, study space, and meeting space. CNMS is assigned a science librarian to assist with research information retrieval, as well as provide training in navigating the library resources to students. The library houses approximately 1 million physical books and journals, plus supplements their collection with electronic media, journals, and databases that are always available to faculty and students online while on or off campus. All services are freely provided to the PI,

****For NSF facilities & Resources include applicable sections below as needed****

Unfunded Collaborators

*NSF requires that any substantial collaboration with individuals not included in the budget should be described in the Facilities, Equipment and Other Resources section and documented in a letter of collaboration from each collaborator. Such letters should be provided as a supplementary document in Research.gov and follow the format instructions specified in [Chapter II.D.2.i\(iv\)](#). Collaborative activities that are identified in the budget should follow the instructions in [Chapter II.E.3](#). *

Senior Personnel

*NSF grants only: if salary and person months are not being requested for an individual designated as Senior Personnel, they should be removed from Section A of the budget. Their name(s) will remain on the Cover Sheet and the individual(s) role on the project should be described in this section (see [PAPPG Section II.D.2.f.i.c](#)). The names of the PI and any Co-PIs will remain on the Cover Sheet even if removed from the budget.