Systems & Options

Magnetic Property Measurement Systems

"We are leading the way with an innovative lab tool called the MPMS. Let me show you how the MPMS can help meet your research goals."

QUANTUM DESIGN

MPMS – Magnetism Workcenter From Quantum Design

"Nothing compares with SQUID sensors for high-sensitivity magnetic measurements. We have integrated this technology into a system that makes it even easier to use."

George Bollendorf
QD Design Engineer

The fundamental study of magnetism is finding an ever-expanding role in the analysis and characterization of materials. From research applications in physics and chemistry, to geology and biology, to the development of the engineering materials of the future, Quantum Design's MPMS (Magnetic Property Measurement System) family sets the performance and reliability standard for these exacting investigations.

Highest Sensitivity

MPMS sample magnetometers employ SQUID (Superconducting QUantum Interference Device) technology, combined with patented enhancements, to achieve superior measurement sensitivity, dynamic range, and reproducibility otherwise unattainable.

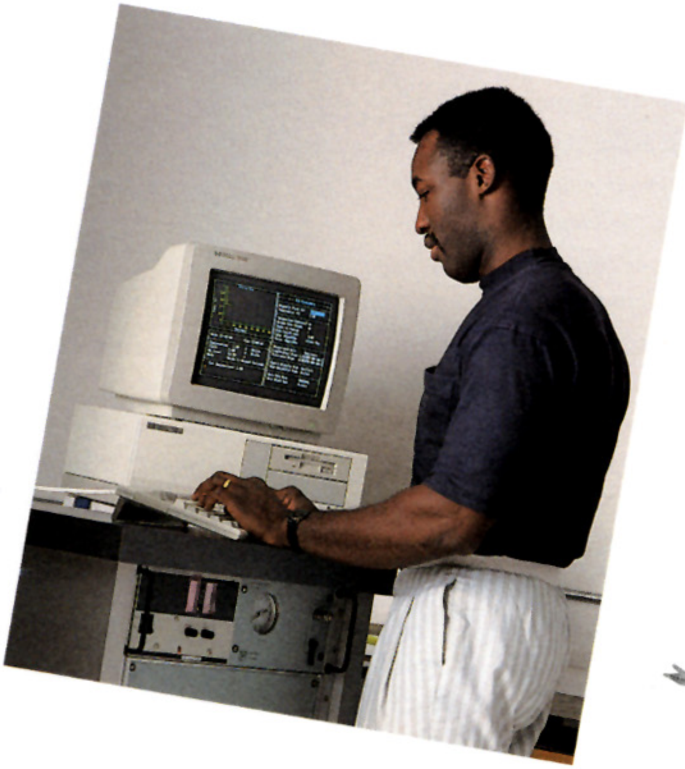
Flexible Operation

The MPMS is designed to fulfill the workcenter concept. It incorporates all the hardware and software needed for precise magnetic measurements in a fully integrated, modular system. For those favoring ease-of-use and short learning curves, windowing menus and color graphics simplify operation. For those requiring deeper involvement, a full suite of software tools allows customization of virtually every instrument parameter. This flexibility allows the user to decide what level of control the system will have running a particular experiment.

Application Versatility

In a multiple-user environment, the MPMS's modular hardware and powerful software permit configuring the system quickly to each user's specific needs, and easily reconfiguring it for the next user. Thus, instead of the space and cost overhead of multiple instruments, a single MPMS can handle a full range of investigations including DC magnetization, AC susceptibility, Hall Effect, resistivity and more.

"Best of all, the MPMS puts you in control. No matter how complex your experiments may be, we can tailor it to your exact needs–which also gives you a lot of flexibility in the future."



Simple Operation

The MPMS measures the moment of a sample by moving it through a liquid helium cooled, superconducting sensing coil. Sample temperature is normally held fixed for each individual measurement. The magnetic field is held fixed for each measurement in DC magnetization studies, and varied by a programmable waveform synthesizer for AC susceptibility analysis.

Easy Data Collection

The Execute Sequence Menu provides users with window-menu options to tailor each measurement to meet specific requirements–including measurement scan length, the number of SQUID measurements, and the number of scans desired to improve signal-to-noise ratios. Simply choosing "Start Measure" implements data collection, computation of moments, and storage of data for future processing.

Automated Measurements

The MPMS is the only system of its kind to offer automated measurement capability–a long series of unattended calculations can be programmed easily. All other systems require manual interaction. This unique capability virtually eliminates the need for late-night lab vigils. Instruction files of up to 1500 steps can be created quickly and easily for immediate use, or stored on disk for later access. Instruction files can be chained together so there is essentially no limit to the programming potential.

"No one has time to sit up all night babysitting an experiment, and with the MPMS you don't have to. Just tell it what tests to run and the rest is automatic."

DC Magnetization

This is the magnetic moment per unit volume (M) of a sample. If the sample doesn't have a permanent magnetic moment, a field is applied to induce one. The sample is then stepped through a superconducting detection array and the SQUID's output voltage is processed and the sample moment computed. Systems can be configured to measure hysteresis loops, relaxation times, magnetic field, and temperature dependence of the magnetic moment.

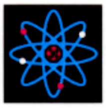
AC Susceptibility

This quantity is sometimes referred to as the differential susceptibility and is the amplitude of a fluctuating magnetic moment induced by a small fluctuating magnetic field - dM/dH. Values measured include real and imaginary susceptibility, which are used to determine frequency dependence and relaxation effects.

MPMS Applications

As instruments and systems have become more sensitive and precise, researchers have pursued a vastly broader range of studies into the magnetic properties of materials. Here are just a few examples of the areas in which the accuracy of the MPMS facilitates these efforts.

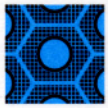
Physics



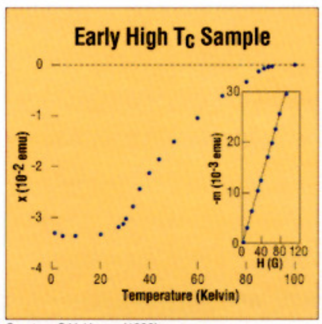
Condensed matter scientists can use the system for low temperature investigations in high magnetic fields. The exceptional dynamic range of the SQUID amplifier allows the MPMS to accommodate samples in many forms, from single crystals to bulk solids and powders. These features, taken together, create a powerful tool for studies of such materials, properties and phenomena as antiferromagnetism, artificially layered structures, biophysics, dichalcogenides, fullerenes, Hall Effect, heavy fermions, high and low temperature superconductivity, hysteresis, Meissner Effect, paramagnetic films, spin glass materials –with more to come as areas of scientific investigations continue to expand.

"The MPMS has become an essential tool for scientists studying superconductivity and other high Tc phenomena."

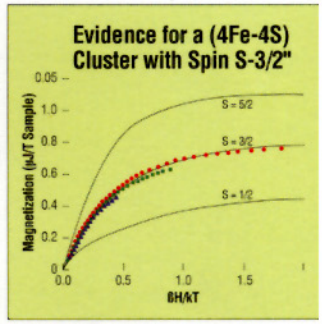
Materials Science



Characterization of the magnetic properties of new materials is central to their evaluation. Not surprisingly, the MPMS is a major tool in the effort to understand and optimize the synthesis process of materials such as amorphous alloys, intermetallic compounds, magneto-optic materials, mesostructures, multilayered materials, nanocomposite materials, organic materials, rare earth compounds, superconductors, superlattices, thin films, transition metal oxides and weakly magnetic materials. A key advantage is the MPMS's ability to provide ultrasensitive, repeatable measurements over a wide range of temperatures and applied fields.



Courtesy C.Y. Huang (1988)



P.A. Lindahl, E.P. Day, et al., J. Biological Chemistry 260, 11160 (1985)

"It's also being used for ground-breaking research in condensed matter and materials science."

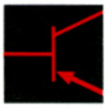
Chemistry

Magnetochemistry focuses on the interrelationship between magnetic fields and atomic and molecular structures. In organic chemistry, analysis of magnetic susceptibility, paramagnetic resonance and other properties aids in evaluating the electronic and magnetic properties of chemicals, such as catalysts and highly complex compounds. The MPMS can be used to examine the properties of materials being synthesized, such as magnetic thin films and superlattices, magneto-optic materials, ceramics, and metalloproteins. The broad temperature range of the MPMS, including its ability to work well above and below room temperature, allows researchers to extend their studies into regimes outside the capabilities of other instruments.

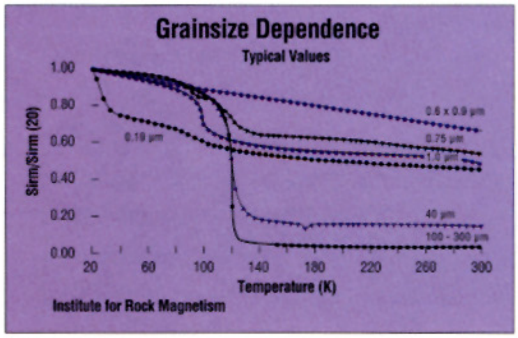
Geology

Analyzing rock samples provides important information about planet Earth–from studying its early history to the dynamic internal changes associated with vulcanism and plate tectonics. For example, inspecting specimens from ancient sea-bed lava flows provides data on periodic reversals in the Earth's magnetic field. Geophysical studies of anisotropy, susceptibility, remanence, coercivity and transformation in samples can require very high temperatures. The MPMS can be tailored to these applications by adding the optional Sample Space Oven which extends temperature capabilities to 800 K. Samples with very high inherent magnetic moments can be measured using the Extended Dynamic Range option.

Electronics



Deeper understanding of the magnetic and electrical properties of materials is crucial to the electronics industry. The focus is on miniaturization, speed and lower heat dissipations–packing devices as closely together as possible to shorten communication distances and boost performance. The study of both LTS and HTS superconductors and semiconducting materials such as Gallium Arsenide is of increasing importance. Magneto-optics, dealing with the influence of magnetic fields on a material's absorption, emission or reflection of light, is also an important new application area.



Institute for Rock Magnetism

The grainsize dependence of the Verwey transition in magnetite (@ 120 K, a magnetocrystalline transition occurs causing remanence to be lost). [SIRM = Saturation Isothermal Remanent Magnetization].

Biology

Growing fields of inquiry include bioelectromagnetism–which investigates the effect of electromagnetic energy on biological systems–and biomagnetism–which analyzes the magnetic fields produced by the living organisms themselves. Fields in the 10^{-14} to 10^{-9} Tesla range result from ion currents in muscles, nerves, and organs such as the brain, lungs and liver and concentrations of iron in animal tissue and chlorophyl. For example, magnetotactic bacteria will swim northward in induced magnetic fields as small as 0.1 Gauss (in comparison, the earth's field at the surface is 0.5 Gauss). Their "internal compass" is a minute amount of iron organized into crystals of magnetite.

"It's incredibly versatile. Whether it's thin film technology or microbiology, you can count on the MPMS for fast and accurate results."

There is also research into the possibility that certain viruses may have magnetic preferences. The study of magnetism plays a role in the design of pharmaceuticals and the understanding of fundamental processes like photosynthesis. Using the MPMS to increase understanding of phenomena like these may lead to the development of enhanced diagnostic and therapeutic techniques.

With all its power, flexibility and ease-of-use, the MPMS design has created a new concept–The Magnetism Workcenter.

The MPMS-2 is the ideal low-field platform, operating in the ± 1.0 Tesla range. It can resolve magnetic moment changes as small as 1E-8 EMU over a wide range of temperatures and applied magnetic fields. Yet its wide dynamic range permits measurement of moments up to 300 EMU. All four systems incorporate a minimal over-shoot heating mode for rapid warming. The result is exceptionally stable control over the entire temperature range. The MPMS-5 is a versatile, general purpose system with a ± 5.5 Tesla field for a wide range of investigations. The MPMS-5S provides a high-uniformity magnetic field well-suited for AC measurements. Operating in the ±5 Tesla range, it serves as an ultra-low field platform. The MPMS-7 expands the peak performance capabilities of this rugged, reliable, flexible family of systems to the ± 7.0 Tesla field range–as well as providing enhanced magnetic field uniformity. All of the MPMS models employ a sealed sample chamber, in which low pressure helium exchange gas establishes thermal contact with the sample, to minimize systematic measurement errors resulting from helium gas displacement when the sample is moved through the coils. A unique implementation of Quantum Design's patented Temperature Control System permits operation in two modes: for rapid cooling it can either over-shoot the target temperature to minimize the time to stabilize after large changes, or never under-shoot the target by more than 0.5% (active from 4.5 to 350 Kelvin for changes of 10 Kelvin or less).

Special Capabilities Are Standard

The range of standard features incorporated into the MPMS makes it the ideal platform for general purpose research with both magnetic and non-magnetic materials. The MPMS makes available a wide range of specialized investigations.

"Using our patented low-temperature control, the MPMS can perform automated measurements even below 4.2K. Because it consumes less liquid helium than other systems, it also lowers your operating costs."

MPMS Model	Standard Resolution	HRC High Resolution
MPMS-2, XL1	0.5 Gauss in ± 1.0 Tesla field	0.05 Gauss in ± 1500 Gauss Field
MPMS-5, -5S, XL5	1.0 Gauss in ± 5.5, ±5.0 Tesla field	0.1 Gauss in ± 5000 Gauss field
MPMS-7, XL7	2.0 Gauss in ± 7.0 Tesla field	0.2 Gauss in ± 6000 Gauss field

High Resolution Control (HRC)

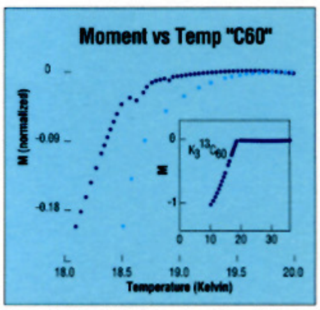
All four MPMS models use HRC to set the superconducting solenoid's field to an accuracy 10 times more precise than the standard resolution (see table). This increased resolution allows for accurate manual compensation of the remanent field for excellent zero-field cooling results, creating an ideal environment for cooling superconducting and spin glass samples.

Low Temperature Control (LTC)

This patented, fully-automated feature offers capabilities not found in other instruments and systems. LTC handles all procedures for setting and controlling temperatures below that of liquid helium. Users can choose any of three modes of operation: standard sequence, manual, or as part of a user-defined program in concert with the optional External Device Control. Operating range is between 4.5 and 1.9 Kelvin, reaching as low as 1.7 Kelvin under manual regulation. LTC offers temperature stability of <0.01 Kelvin, at 4.2 Kelvin, and <0.5% at 1.9 Kelvin. Running time below 4.4 Kelvin is typically at least 1 hour.

Hysteresis Measurement Control (HMC)

Changes in the magnetization of a sample under investigation can lag behind changes in the applied magnetizing force–a process called magnetic hysteresis. HMC hardware and firmware, standard with the MPMS, facilitate studying magnetic hysteretic phenomena with samples having moments of 1E-5 EMU and above. The HMC makes a measurement and records the results in as little as 15 seconds–faster than similar systems. So users can accelerate the data collection rate for large samples, and rapidly generate magnetic hysteresis loops.



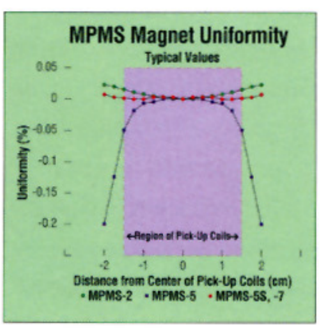
Charles M. Lieber & Chia-Chun Chen, Harvard University

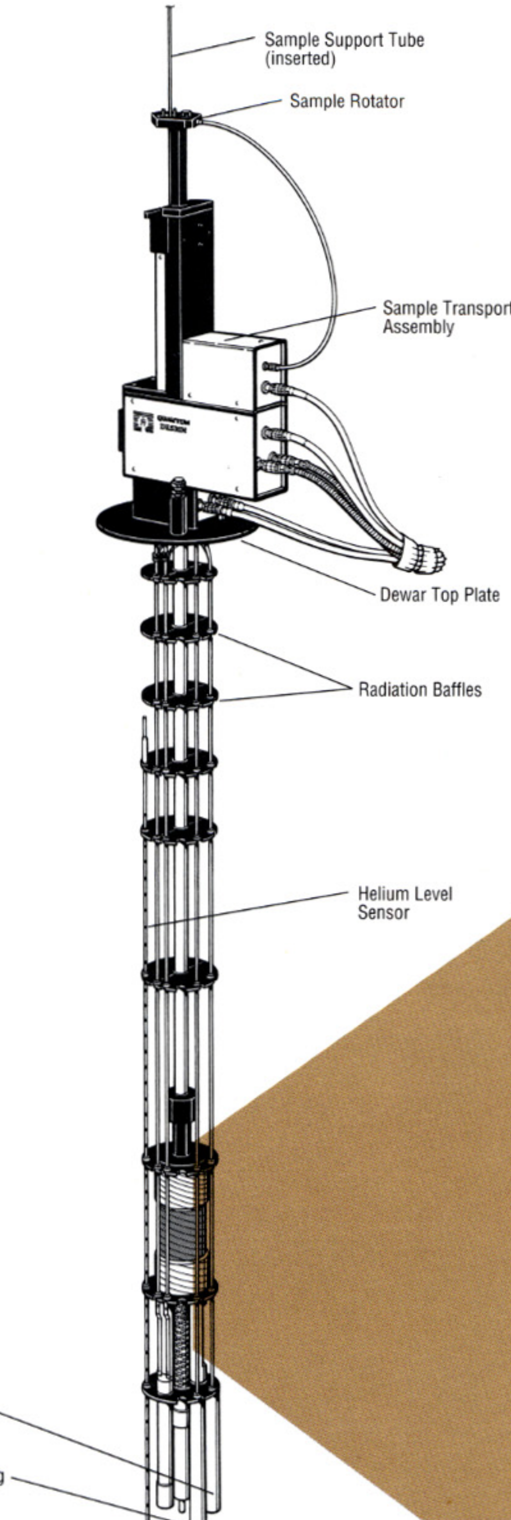
High-resolution temperature dependent magnetization measurements obtained on $K_3{}^{13}C_{60}$ (●) and $K_3{}^{12}C_{60}$ (■) samples highlighting the depression in T_c for the isotopically substituted material. The samples were initially cooled in zero field to 5K and then the curves were recorded on warming in a field of 20 Oe. The curves were normalized to the value of the magnetization at 5K. The inset shows a typical magnetization curve for a $K_3{}^{13}C_{60}$ sample.

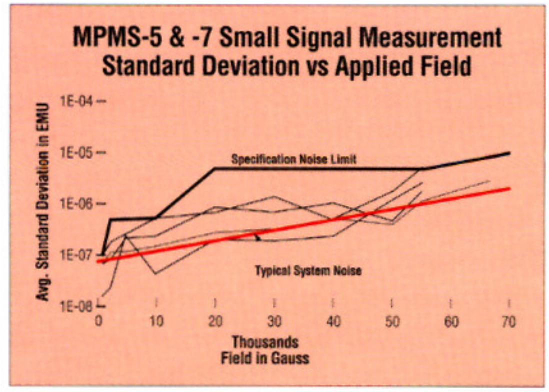
MPMS Specifications

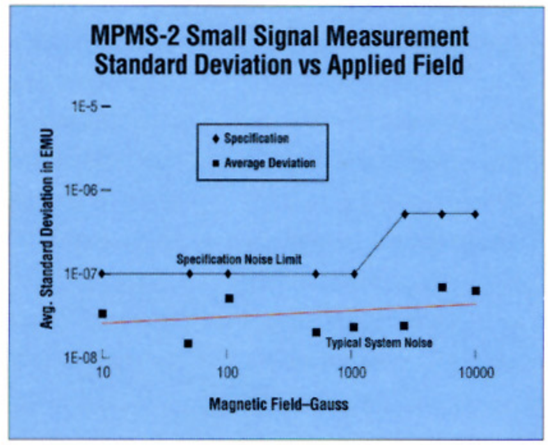
System Design

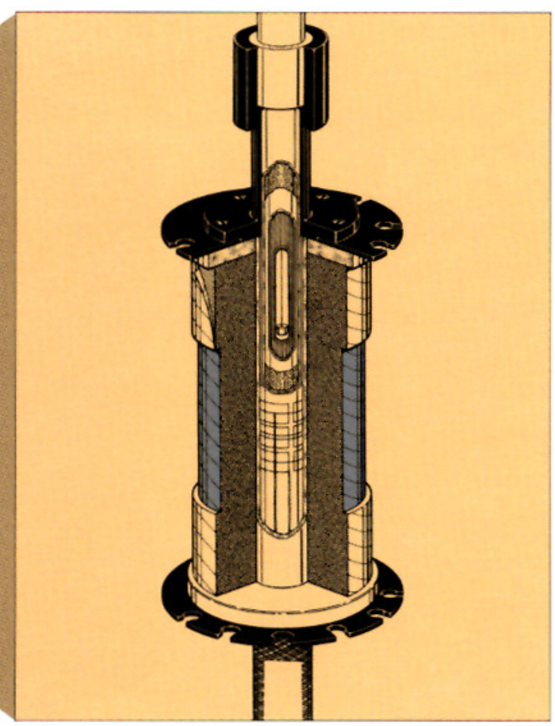
The MPMS family of magnetometers offers excellent sensitivity, field uniformity, repeatability, accuracy and reliability. Four models are available with magnetic field ranges from ±1 Tesla to ±7 Tesla, including ultra-low field options and AC/DC measurement capabilities. The modular MPMS design integrates a SQUID detection system, a precision temperature control unit residing in the bore of a high-field superconducting magnet, and a sophisticated computer operating system. Powerful software makes measurements, data collection and analysis quick and easy. Window-menu prompts and options lead the user through each step. When keyboard input is required, the system specifies what parameters should be entered, the appropriate units, and the allowable range of values.











MPMS Option Specifications

Option M101A

Transverse Moment Detection System

The standard MPMS configuration employs a single SQUID sensor to measure magnetic moments aligned parallel with the applied field. To examine the anisotropic effects of moments with vector components perpendicular to the applied field, a Transverse Moment Detection System option may be added. It incorporates a second SQUID detection system which can resolve transverse moments as small as 1E-6 EMU. The transverse superconducting coil array is wound in a second-derivative configuration orthogonal to the longitudinal detection coils–with both coil sets sharing a common center position. Thus, the user can easily specify the use of longitudinal, transverse or both SQUID systems for programmed measurement sequences.

Dynamic Range:
1E-6 to >1.5 EMU; option to 300 EMU

Detection Loop:
d^2B_x/dz^2 Array
(second derivative configuration)

Calibration Accuracy:
1% absolute

"You can even investigate magnetic anisotropy with our Transverse Moment Detection and Rotator options."

Option M101B

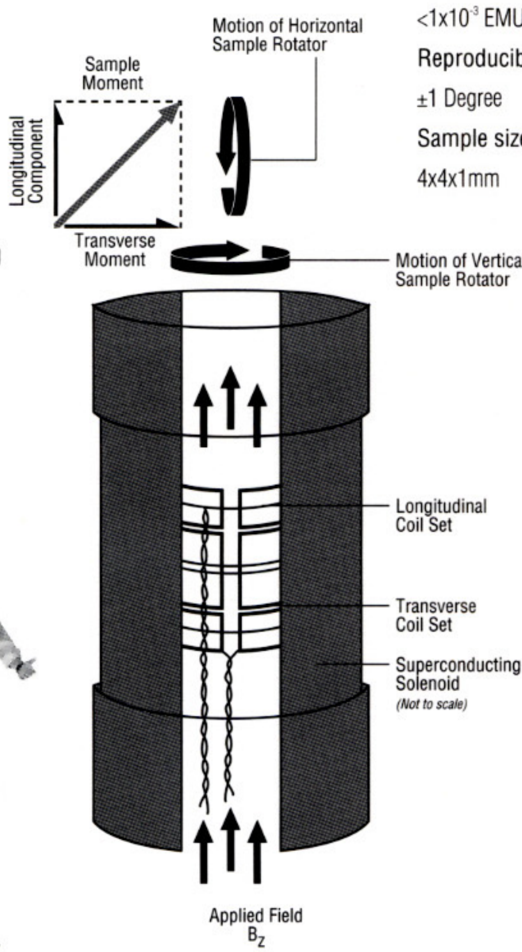
Vertical Sample Rotator

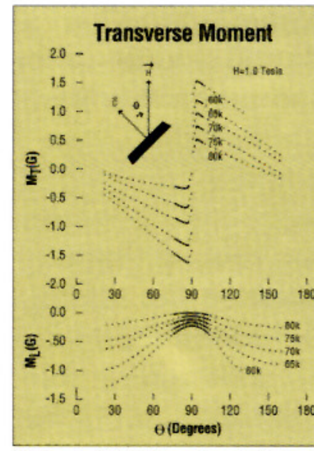
This Vertical Sample Rotator permits users of the Transverse Superconducting Coil Set to rotate samples ±360 degrees about the longitudinal axis of the solenoid under computer control, facilitating such activities as 3-axis measurements of a sample. Sample orientation can be specified within 0.1 degrees under either computer or manual control.

Range of Motion:
±360 Degrees

Slew Rate:
45 Degrees per second

Angular Positioning Resolution:
±0.5 Degrees





Transverse and longitudinal magnetization as a function of Θ for a $Bi_2Sr_2CaCu_2O_y$ crystal cooled in a 1.0 Tesla field. Longitudinal and transverse moments are measured simultaneously with separate pick-up coils.

M.T. Tuominen & A.M. Goldman, University of Minnesota

Option M101C

Horizontal Sample Rotator

The Horizontal Sample Rotator is used for rotating a sample with respect to the magnetic field. This option, which requires the Vertical Sample Rotator (M101B), will rotate a thin film (or other small sample) for measuring the magnetic moment versus angular position.

Rotation:
0 to 360 Degrees
in 0.1 Degree Increments.

Background:
Linear & Diamagnetic
$<1x10^{-3}$ EMU @ 5T

Reproducibility:
±1 Degree

Sample size:
4x4x1mm

Option M102

Sample Space Oven

MPMS magnetic moment measurements can be made at temperatures from ambient to 800 Kelvin through use of the optional Sample Space Oven. Operation is completely automated through control software which is fully integrated into the MPMS operating system. The Oven is an insulated heater assembly which is introduced directly into the normal MPMS sample space. Its sample space is 3.5 mm in diameter. Because the Oven employs a vacuum sleeve to isolate high temperatures from the standard MPMS temperature control system, the normal sample space remains below room temperature–minimizing helium requirements when operating the Oven for extended experiments. The Oven can be quickly and easily installed or removed as needed.

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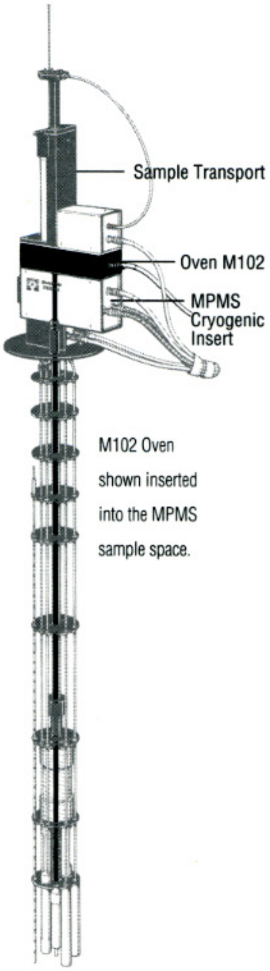
MPMS Option Specifications



M102 Oven shown inserted into the MPMS sample space.

Sample Tube Inner Diameter:
3.5mm
Temperature Range:
Ambient to 800 Kelvin
Temperature Accuracy:
±0.5% (Typical) at 800 Kelvin
Temperature Uniformity:
±0.5% (Typical) over 6cm length centered at coils
Sample Run Out:
5 inches (center of measuring coils to oven bottom)
Thermometer Element:
Platinum
Helium Usage:
Approximately 0.1 liters per hour

Option M104

Magnet Reset

Magnetic fields in the MPMS are produced by precisely controlling current in the superconducting solenoid. Typically, a residual or remanent field of 3 to 5 Gauss remains in the superconducting solenoid after operation at high fields–even when the current is oscillated to zero (this can be 10 times larger if the "No-Overshoot" mode is used). The Magnet Reset option can be used to "quench" the superconducting magnet, reducing the remanent field to less than 2 Gauss.

MPMS-5

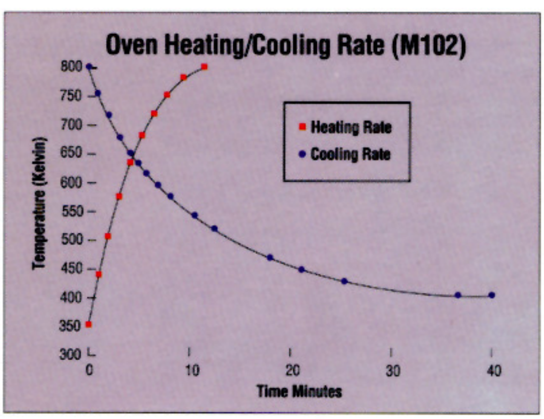
In the MPMS-5, the Magnet Reset option is activated after the superconducting solenoid is charged to a field of 3.5 Tesla. The Reset option then uses the energy stored in the magnet to warm the solenoid above its critical temperature. During a Reset operation, the total liquid helium boil-off is typically less than 0.5 liters of liquid helium.

Remanent Field after Reset:
< 2 Gauss (Typical)
Time to Re-Cool Magnet:
< 3.0 minutes
Minimum Operating Helium Level:
50% (approximately 28 liters)
Dewar Boil-off:
< 1 liter (Typical)

MPMS-5S & 7

The MPMS-5S and MPMS-7 superconducting solenoids contain an internal heater. This heater is used to quench the solenoid when it has been discharged to zero current. By not dissipating the energy from the solenoid in the liquid helium bath, these larger, high-uniformity magnets can be quenched with only 0.5 liters loss of liquid helium.

Remanent Field after Reset:
< 2 Gauss (Typical)
Time to Re-Cool Magnet:
< 3.0 minutes
Dewar Boil-off:
< 0.5 liters (Typical)



Option M105

Extended Dynamic Range (EDR)

This unique EDR option expands MPMS full-scale measuring capabilities to ± 300 EMU. With this option, magnetic properties of materials can be examined over a dynamic range exceeding 10^{10} EMU. The extended capability is particularly useful for single-instrument analysis of bulk ferromagnetic materials, and thin films of materials with inherently large magnetic moments. The EDR operating mode can be activated selectively, and doesn't compromise the high sensitivity available for samples with much smaller moments.

Range of Measurement:
1.25 to > 300 EMU
Helium Usage:
0.4 liters in 12 hours when option is activated

"The Magnet Reset lets you create a low-field environment even within a high-field superconducting magnet. Or use the Extended Dynamic Range feature for samples with a wide range of magnetic moments."

MPMS Option Specifications

Option M106

External Device Control (EDC)

EDC is a powerful, yet easy-to-use programming language for selecting devices, evoking device functions, and sending or receiving data–as well as accessing such MPMS functions as control of temperature and magnetic field. EDC also supports real and string variables, and allows mathematical and string operations. This versatile option provides access to MPMS precision temperature and magnetic field controls, which serve as an experimental platform for the measurement of resistivity, magneto-resistance, Hall Effect and other subtle physical properties. EDC is fully integrated with the MPMS control software.

Resistivity & Hall Effect Package

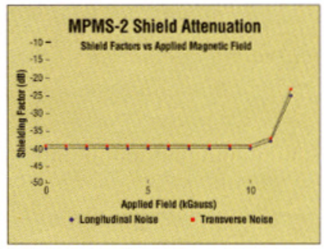
Resistivity and Hall Effect equipment is also available for use with the MPMS to facilitate these measurements. Each consists of a voltmeter, current source, External Device Control, and Manual Insertion Utility Probe. Sample External Device Control programs are also available.

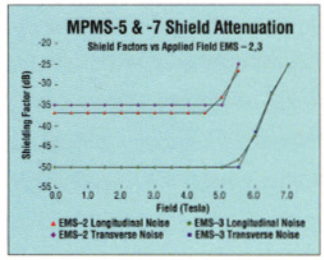
Option M107

Environmental Magnetic Shield (EMS)

The EMS allows very sensitive MPMS measurements to be made in locations with excessive magnetic noise by creating a locally quiet environment. The EMS also serves as a return path for the MPMS superconducting solenoid, permitting use of the system in close proximity to other sensitive instruments. The installed shield does not require degaussing after repeated full-field operation. It fits around the dewar inside the standard MPMS dewar cabinet–and both are suspended to provide vibration isolation. The EMS is available for both new and existing systems.

MPMS Model	EMS Model	Construction
MPMS-2	EMS-1	1 layer μ-Metal
MPMS-5 **MPMS-5S**	EMS-2	1 layer μ-Metal; 1 iron inner shield
MPMS-7	EMS-3	1 layer μ-Metal; 2 iron inner shields





Option M120

AC Susceptibility Measurement

This option turns an MPMS into a complete magnetism workcenter. All phases of research into both magnetism and magnetic properties of materials, are possible. Many materials display dissipative mechanisms when exposed to an oscillating magnetic field, and their susceptibility is described as having real and imaginary components–the latter being proportional to the energy dissipation in the sample. The key is resolving the component of the sample moment that is out of phase with the applied AC field. The SQUID technology of the MPMS is the measurement system of choice because it offers a signal response that's virtually flat over a broad frequency range from 0.01 Hz to 1 kHz. In a SQUID system, the output voltage is proportional to the magnetic flux in the pickup coil instead of its time derivative. The MPMS, therefore, is able to achieve a minimal variation in sensitivity over the entire frequency range, and

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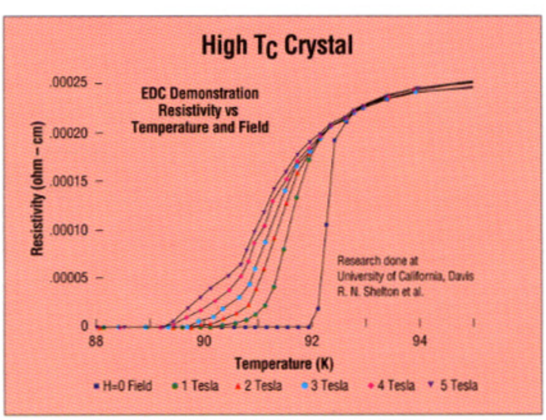
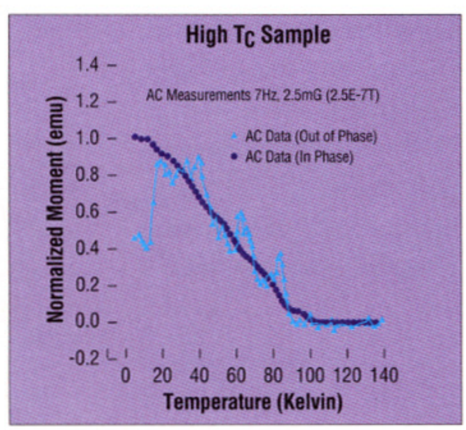
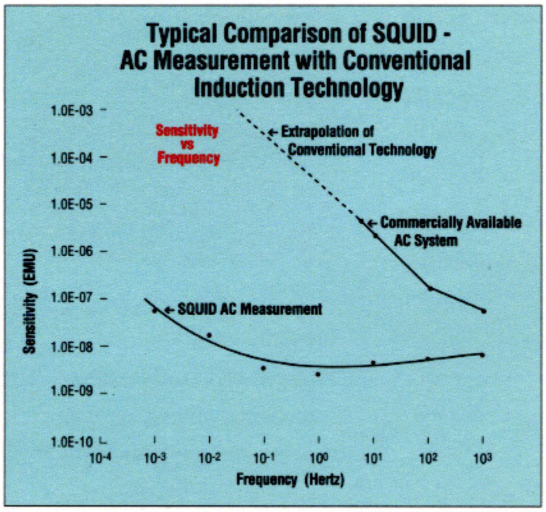


"For the real MPMS 'power users' in your lab, the EDC option gives you an even greater degree of control and customization."



MPMS Option Specifications



opens up new regimes for scientific study. This is in contrast to conventional AC systems where signal sensitivity depends on measurement frequency. The AC Measurement option adds the ability to evaluate AC susceptibility by upgrading the system controller, and incorporating a Programmable Waveform Synthesizer plus a high-speed Analog-to-Digital converter. AC susceptibility is measured automatically by (1) applying an AC field to the sample, (2) digitizing the SQUID system's output, (3) programming the Waveform Synthesizer to generate the proper compensation feedback, and (4) digitally recording the sample's AC response. AC response voltage readings can be recorded in a data file, or processed using the system's advanced digital techniques to determine the real and imaginary components of the sample's susceptibility. The MPMS's SQUID detection system provides full 1E-8 EMU sensitivity through the entire AC measurement frequency spectrum–a significant advantage over non-SQUID systems.

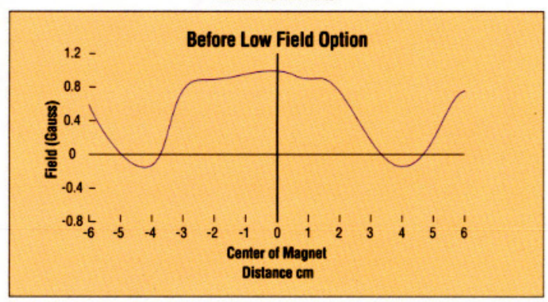
Option M125

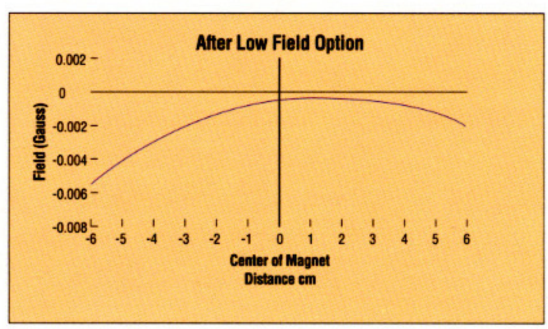
Ultra-Low Field Capability

This option actively cancels residual magnetic flux in the MPMS-2 or MPMS-5S's superconducting solenoid so samples can be cooled in a very low field–typically less than 0.005 Gauss in the MPMS-2 and 0.05 Gauss for the MPMS-5S. This capability is extremely important for measurements of high temperature superconductors and spin-glass materials. It can also be used in concert with the External Device Control option for the measurement of resistivity and other transport property measurements. The Low Field option incorporates additional electronics for the system's controller, and a custom magnetometer specifically designed for this application. In operation, the MPMS measures the residual field and then nulls it by setting a compensating DC field, using a drive coil installed in the superconducting solenoid. The result in the MPMS-2 solenoid is 5 milligauss along the longitudinal axis (<2.0 milligauss typical) and 10 milligauss along the transverse axis (<5.0 milligauss typical). The Ultra-Low Field option requires use of the Environmental Magnetic Shield (EMS) option which both reduces excessive environmental magnetic noise by creating locally quiet conditions, and screens out the earth's ambient field.

Also available for MPMS-7, XL7.

Low Field Plots





	MPMS-2, XL1	MPMS-5S, XL5	MPMS-7, XL7
AC Frequency Range	0.01 Hz to 1 KHz	0.01 Hz to 1 KHz	0.01 Hz to 1 KHz
AC Field Strength	2E-4 to 3 Gauss	2E-4 to 2 Gauss	2E-4 to 5 Gauss
Sensitivity	0.1 Hz to 1 KHz @ 1 Tesla: 1E-8 EMU	0.1 Hz to 1 KHz @ 1 Tesla: 1E-8 EMU 0.1 Hz to 1 KHz @ 5 Tesla: 5E-8 EMU	0.1 Hz to 1 KHz @ 1 Tesla: 1E-8 EMU 0.1 Hz to 1 KHz @ 7 Tesla: 7E-8 EMU
DC Applied Field	0.005G* to 10K Gauss	0.05G* to 50K Gauss	0.05G* to 70K Gauss

*(when using M125 Ultra Low Field Option)

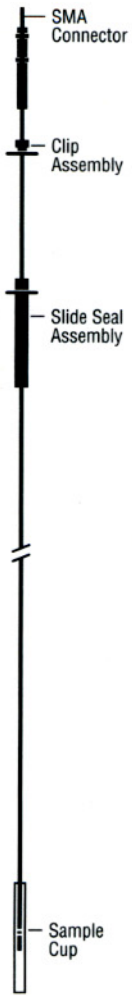
Note: All sensitivity tests were done with either an EMS-1 or EMS-2 Shield. The M120 option is not compatible with the transverse option M101A for the MPMS-5S.

MPMS Option Specifications

Option C010

Fiber Optic Sample Holder

The Fiber Optic Sample Holder provides a convenient way to study the magnetization of a sample under the influence of light. It connects easily to an optical fiber from a laser or other high powered light source, so the user can illuminate a sample in the sample space. During and after illumination, the MPMS can measure magnetization over a wide range of temperatures and magnetic fields.



Numerical Aperture:
0.22±0.02
1.5mm Core

Part Number:
Fiberguide Industries
Fiber: SFS1500-1650N
SUPERGUIDE G UV-Vis Fiber
(Optional ANHYDROGUIDE G Fiber available)
Flexible Bundle: SFB200/220T

Connector:
Flexible Bundle: SMA

Length:
Flexible Bundle: 2 meters

Option C020

Low Field Profiling Option

The Low Field Profiling option measures the remanent magnetic field in the MPMS superconducting solenoid. This allows the user to establish controlled measurement conditions before introducing a field sensitive sample, such as high temperature superconductors or spin glasses into the MPMS. The Low Field Profiling option allows the user to map the field uniformity at low magnetic fields and to measure the absolute field at a given position. Using the Low Field Profiling option and manually setting the magnetic field, one can achieve very low field conditions (given the High Resolution field setting precision of the MPMS), or precisely set fields up to ±10 Gauss. This option is available for either Revision 1.X MPMS software operating systems, or the new highly versatile Revision 2 software control system. For Revision 1.X, the option comes with a custom designed fluxgate magnetometer, and a BNC output jack for interfacing to a chart recorder or other analog data recorder (not supplied). For MPMS with Revision 2, the option includes the fluxgate and BNC connector, and additional cabling to interface the fluxgate with the MPMS 1822 controller. Revision 2 software can scan and plot the field profiles, and allow manual field changes. The fluxgate extends down into the bore of the superconducting solenoid as would a sample rod. In this way, the MPMS Sample Drive does automated field profiling. Standard with the option, is a wall-mounted holder with a μ-metal shield, for zeroing the fluxgate before each use.

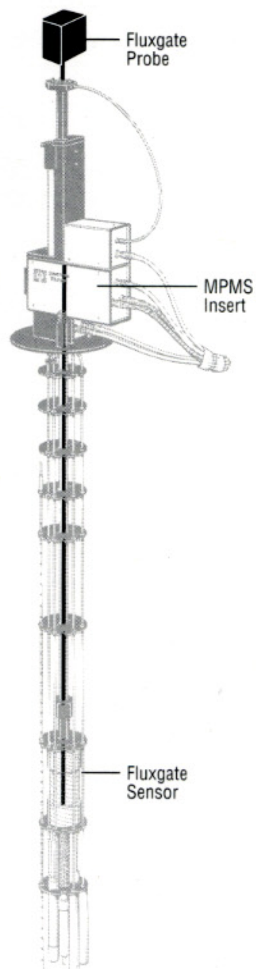
Fluxgate Range:
±10 Gauss

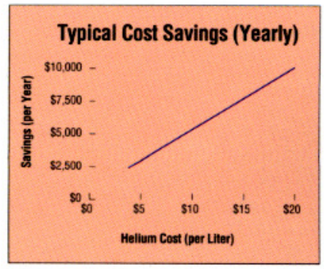
Sensitivity:
±0.01 Gauss

Battery Type:
9 Volt

Average Battery Life:
3-4 Hours

Voltage Output:
±1 Volt (1 Gauss=0.1 Volts)





Option C030

Nitrogen Jacketed Dewar

This option is designed to reduce operating costs and extend liquid helium hold time. The Nitrogen Jacketed Dewar was engineered to fit the MPMS cabinet and environmental magnetic shields, and is fully compatible with all of the other MPMS options. The nitrogen tank holds about 20 liters of liquid and lasts about seven days. Users working below 200 Kelvin will benefit the most from this option. Reduction in liquid helium consumption can be as much as 30 percent for users working in the low temperature range.

"There's no end to the range of experiments and conditions possible with the MPMS. We have options that support all kinds of measurements, from 2 to 800K, from.0.005G to 70KG."

MPMS Option Specifications

Options–Reference Chart

PRODUCT	MODEL	XL1 MPMS-2	OBSOLETE MPMS-5	XL5 MPMS-5S	XL7 MPMS-7
Transverse Moment Detection System	M101A		-5	-5S	-7
Vertical Sample Rotator	M101B	-2	-5	-5S	-7
Horizontal Sample Rotator	M101C	-2	-5	-5S	-7
Sample Space Oven	M102	-2	-5	-5S	-7
5 Tesla Magnet Reset	M104		-5	-5S	
7 Tesla Magnet Reset	M104				-7
Extended Dynamic Range (EDR)	M105	-2	-5	-5S	-7
External Device Control (EDC)	M106	-2	-5	-5S	-7
EMS - 1 Environmental Magnetic Shield	M107	-2			
EMS - 2 Environmental Magnetic Shield	M107		-5	-5S	
EMS - 3 Environmental Magnetic Shield	M107				-7
7 Tesla Upgrade	M110		-5	-5S	
1 to 5 Tesla Upgrade	M112	-2			
1 to 7 Tesla Upgrade	M113	-2			
5 Tesla Upgrade	M115		-5		-7
SQUID AC Susceptibility Measurement*	M120	-2		-5S	
Ultra-Low Field Capability*	M125	-2		-5S	
Reciprocating Sample Measurement System (RSO)	M130	-2	-5	-5S	-7
Continuous Low Temperature Control (CLTC)	M140	-2	-5	-5S	-7
Fiber Optic Sample Holder	C010	-2	-5	-5S	-7
Low Field Profiling Option	C020	-2	-5	-5S	-7
Nitrogen Jacketed Dewar	C030	-2	-5	-5S	-7
Sample Support Assemblies (set of 3)	C110	-2	-5	-5S	-7
Manual Insertion Utility Probe	C111	-2	-5	-5S	-7

*Not compatible with M101A

"Pick and choose the options that are right for you–without paying for features you don't need."

MPMS Option Specifications

Systems–Reference Chart

DESCRIPTION†	MPMS-2**	MPMS-5**	MPMS-5S**	MPMS-7**
Field Range	± 1.0 Tesla (10,000 Gauss)	± 5.5 Tesla (55,000 Gauss)	±5.0 Tesla (50,000 Gauss)	±7.0 Tesla (70,000 Gauss)
Field Stability	1ppm/hour	1ppm/hour	1ppm/hour	1ppm/hour
Intrinsic Field Uniformity *(4cm: ± 2cm from center of pickup coil)*	0.03% for > 100 Gauss fields; 0.03 Gauss for < 100 Gauss fields	0.03% over length of measuring coils (3cm)	0.02% over (4cm)	0.01% over (4cm)
Field setting resolution *(Gauss)*	0.5 G to 10,000 G 0.05 G to 2,000 G	1 G to 55,000 G 0.1 G to 5,000 G	1 G to 50,000 G 0.1 G to 5,000 G	2 G to 70,000 G 0.2 G to 6,000 G
Residual field *(Gauss)* *Oscillate Mode* / *No Overshoot Mode*	< 1 G typical < 10 G typical	< 5 G typical < 20 G typical	< 5 G typical < 20 G typical	< 5 G typical < 30 G typical
Maximum Calibrated Sample Size *(Sample Chamber ID)*	9mm	9mm	9mm	9mm
DC Magnetization				
Differential sensitivity *(minimum resolvable change in magnetic moment, 1E-4 EMU range)*	1E-8 EMU	1E-8 EMU to 1 Tesla 1E-7 EMU to 2 Tesla 5E-7 EMU to 5 Tesla	1E-8 EMU to 1 Tesla 1E-7 EMU to 2 Tesla 5E-7 EMU to 5 Tesla	1E-8 EMU to 1 Tesla 1E-7 EMU to 2 Tesla 1E-6 EMU to 7 Tesla
Absolute sensitivity *(minimum detectable moment)*	±1E-7 EMU to 1 Tesla	±1E-7 EMU to 1 Tesla ±5E-7 EMU to 5 Tesla	±1E-7 EMU to 1 Tesla ±5E-7 EMU to 5 Tesla	±1E-7 EMU to 1 Tesla ±1E-6 EMU to 7 Tesla
Range of measurement	±2.0 EMU (option to ±300 EMU)	±2.0 EMU (option to ±300 EMU)	±2.0 EMU (option to ±300 EMU)	±2.0 EMU (option to ±300 EMU)
AC Susceptibility (MPMS-2, 5S with M120 & M107)				
Sensitivity *0.1 to 1KHz*	1E-8 EMU to 1 Tesla		1E-8 EMU to 1 Tesla 5E-8 EMU to 5 Tesla	
Temperature range at the sample space *(Kelvin)*	1.9 K to 350 K Option to 800 K	1.9 K to 400 K Option to 800 K	1.9 K to 400 K Option to 800 K	1.9 K to 400 K Option to 800 K
Temperature calibration accuracy at the sample space	±0.5% typical	±0.5% typical	±0.5% typical	±0.5% typical
Temperature stability at the sample space *(Kelvin)*	< 0.05 K @ 300 K < 0.01 K @ 5.0 K	< 0.05 K @ 300 K < 0.01 K @ 5.0 K	< 0.05 K @ 300 K < 0.01 K @ 5.0 K	< 0.05 K @ 300 K < 0.01 K @ 5.0 K
Temperature spatial variation in sample chamber *(Kelvin)*	±0.1 K over 8cm ±1.0 K over 15cm @ 235 K	±0.1 K over 8cm ±1.0 K over 15cm @ 235 K	±0.1 K over 8cm ±1.0 K over 15cm @ 235 K	±0.1 K over 8cm ±1.0 K over 15cm @ 235 K
Rate of temperature change in 30 min. *typical (Kelvin)*	300 K to 5 K 5 K to 300 K	300 K to 5 K 5 K to 300 K	300 K to 5 K 5 K to 300 K	300 K to 5 K 5 K to 300 K
Helium capacity *(Liters)*	56	56	56	56
Helium usage* Standard Super Insulated Dewar *(Liters/day)*	5	5.5	5.5	6
Optional Nitrogen Jacketed Dewar *(Liters/day)*	3.7	4.2	4.2	4.5

*Based on average usage–including Temperature & Field Sweeps run 24-hours a day.

**Obsolete System

† Technical specifications are subject to change without notice.

An Organization You Can Count On

In the decade since it was founded, Quantum Design has become the leader in developing and delivering technologically superior SQUID-based instruments and systems. Together with its sister organization, Quantum Magnetics, it provides a full spectrum of scientific and engineering support for customers internationally.

Quantum Magnetics serves as the basic research arm of the organization - performing contract research for a broad range of agencies within the U.S. Government and commercial companies, in addition to R&D work for Quantum Design. As such, Quantum Magnetics' scientists keep in constant touch with leading scientists around the world. They furnish unique insights into new and existing product and performance requirements. Quantum Design's charter is to create, engineer, market and support leading-edge systems and instruments based on a solid foundation of advanced technology. Since 1985, the MPMS has expanded from a single 5.5 Tesla instrument to a family of systems - adding 1 Tesla, 5 Tesla, and 7 Tesla models, plus key options to broaden overall MPMS capabilities. Parallel developments include advanced software using windowing menus to make the system's superior sensitivity and application versatility even easier to access.

Quantum Design's new Physical Property Measurement System, PPMS, provides a flexible temperature and magnetic field platform to perform a wide range of electrical, thermal and mechanical measurements. The PPMS also offers an optional AC susceptibility and DC magnetization module for a complete, turnkey solution for the most exacting susceptibility and magnetization experiments.

Quantum Design's family of SQUID Sensors Electronics & Systems brings the same levels of high performance and ease of use to this investigative area. This product line features a unique microprocessor-powered control module employing a front-panel display plus control keys to operate and monitor one to

" We are dedicated to providing our customers with the most advanced measurement systems, instruments and components."

eight SQUID channels simultaneously. Quantum Design's patented SQUID manufacturing process and design, electronics, and integrated systems, represent a new generation of instruments and components that will form the heart of future SQUID measurement systems for military, commercial and research applications.

The Quantum Design commitment is to provide our customers with the most advanced measurement systems, instruments and components possible. The MPMS is proof of our technological leadership today–and a tangible promise of the advances we intend to introduce in the future.

Customer Service & Support

Comprehensive Testing

As part of Quantum Design's commitment to superior quality, each instrument is subjected to over 400 individual tests and inspections before shipment.

Installation Assistance

An Installation Specialist is dispatched to each new MPMS facility to ensure proper set-up and complete system functionality. The Specialist reviews all operating procedures with laboratory staff, as well as providing a package of product support materials designed to speed and simplify the learning process.

Technical Support

Should a problem arise, a Technical Support Representative is assigned to work with the user until a question is resolved. Each Representative is also backed by Quantum Design's scientific and system design staff.

Toll-Free Phone

Quantum Design's toll-free 800-289-6996 telephone support line is available 24 hours a day. Calls outside normal 8am -5pm PST, Monday-Friday business hours are recorded for response the next business day.