Ho-kwang (David) Mao

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Born: June 18, 1941, Shanghai, China **Citizenship:** U.S.A. since 1976

Education:
Ph.D. (1968), M.S. (1966) University of Rochester, Rochester, N.Y., USA
B.S. (1963) National Taiwan University, Taipei, Taiwan, Republic of China

Experience:
Staff (1972-present), Geophysical Laboratory, CIW
Postdoc and Research Associate (1968-72), Geophysical Laboratory, CIW

Research Areas
Ultrahigh pressures and temperatures-- As a fundamental physical variable, high pressure alters all states of matter, but for many years, its effects were poorly understood due to experimental limitations: either the pressure was too low to cause significant changes, or samples under high pressure could not be subjected to thorough analyses. Advances in diamond-cell technology led by Ho-kwang Mao have changed this prospect. He reached and calibrated static high pressures of several megabars in the laboratory -- an order of magnitude higher than the previous maximum set by P.W. Bridgman. With colleagues, Mao developed double-side laser-heating, resistive heating, and cryogenic techniques to cover 35 mK to 6000 K temperature range at simultaneous high pressures.

Multidisciplinary, multiple probe, high- pressure science-- For investigations of new phenomena through the diamond windows, Mao and coworkers developed an unprecedented array of synchrotron, laser, and electromagnetic probes for accurate *in-situ* measurements with Brillouin, Raman, infrared, and optical absorption spectroscopy, x-ray diffraction, x-ray spectroscopy, electrical conductivity, magnetic susceptibility, and nuclear magnetic resonance spectroscopy at high pressures and temperatures. Resultant discoveries in physics, chemistry, geoscience, and materials science have, in effect, added the new pressure dimension to science and technology.

Geophysics and Mineral Physics -- In order to study the Earth's interior, we must understand its constituents, ordinary minerals whose physical and chemical properties have been drastically changed by the extreme high-pressure conditions which prevail at great depth. Mao and coworkers reached the Earth's core *P-T* conditions and obtained structural, elastic, rheological, chemical and electronic properties of over 100 oxides, sulfides, silicates, hydrous minerals, metals, and alloys. They measured the Fe/Mg partitioning between $(Fe,Mg)SiO_3$-perovskite and ferropericlase in the Earth's lower mantle as a function of pressure, temperature, bulk Fe/Mg ratio, and ferric iron content. They determined the phase diagram and melting curve of iron at the *P-T* conditions of the molten outer core, resolving the decade-long controversy. They developed a radial x-ray method for elasticity tensors, lattice preferred orientation and strength determinations of iron to the Earth's core pressures. They developed high-pressure nuclear resonant x-ray inelastic scattering method to measure the phonon density of state of Fe and ferromagnesian silicate post-perovskite determined shear and compressional velocities,

and vibrational thermodynamic properties to D" and core pressures. They developed high-pressure x-ray emission spectroscopy as a diagnostic tool for discovery of the long sought-for pressure-induced, iron spin-pairing transitions that govern element differentiation, elasticity, and radiative heat transfer in the deep mantle. These studies have provided crucial information for constraining static and dynamic models of the Earth's deep interior.

Planetary physics and condensed matter physics -- Mao and coworkers explored the high-pressure behaviors of hydrogen — the most abundant element in the solar system, compressed H_2 into solid, determined its crystal structure, and discovered numerous intriguing high-pressure phenomena, including vibron turnover, bound-unbound transition, quantum and classical orientation orderings, an invariant point, a critical point, and intense charge transfer. They determined melting and elasticity of H_2 and He to constrain planetary seismic models. They discovered multiple new phases and observed cascading Fermi resonance, hydrogen bond symmetrization, and superionic transition in H_2O.

Mao and coworkers studied a wide variety of insulators, semiconductors, metals, superconductor, and ferroelectrics, and observed drastic pressure-induced changes of optic, phonon, electronic, and magnetic behaviors. For instance, they compressed ceramic superconductor to record-high *Tc* of 164 K, and elemental Li, B, and S into record-high elemental *Tc* superconductors from 10 to 17 K.

High-pressure chemistry and crystallography -- Mao and coworkers discovered and identified many new phases including novel van der Waals compounds and chain structure in Group VI elements, and pioneered studies of pressure-induced amorphization and coordination changes in glasses. They observed dramatic changes of chemical reactivity and bonding, and synthesized numerous new materials that redefine the chemical properties of the Periodic Table at each pressure interval. Their discovery of hydrogen clathrate leads to new method for hydrogen storage, and his development of rapid CVD single-crystal diamond growth impacts on a whole array of technology using the unique properties of large diamond crystals.

Elected Memberships and Fellowships:

Member of National Academy of Science, U.S.A. 1993 –
Member of Academia Sinica, Republic of China (Taiwan), 1994 -.
Foreign Member of Chinese Academy of Sciences, People's Republic of China, 1996-.

Fellow of American Geophysical Union, Fellow of American Physical Society, Fellow of European Association for Geochemistry, Fellow of Geochemical Society, and Fellow of Mineralogical Society of America.

Major Awards:

Inge Lehmann Medal, 2007, American Geophysical Union (Geophysics)
Balzan Prize, 2005, Balzan Foundation, Italy and Switzerland (Mineral Physics)
Gregori Aminoff Prize, 2005, Royal Swedish Academy of Sciences (Crystallography)
Roebling Medal, 2005, Mineralogical Society of America (Mineralogy)
Arthur L. Day Prize, 1990, National Academy of Science (Geophysics)
P. W. Bridgman Gold Medal Award, 1989, Association Internationale pour Avancement de la Recherche et de la Technologie aux Hautes Pressions (AIRAPT) (High Pressure Science and Technology)

Mineralogical Society of America Award, 1979 (Mineralogy)

Recent Synergetic Activities (selected):

United States of America

2007-present, Director, High Pressure Synergitic Center (HPSynC); 1998-present, Director, High Pressure Collaborative Access Team (HPCAT) at Advanced Photon Source, Argonne National Lab.

2003-present, Co-PI of the high-pressure instrument at Spallation Neutron Source (SNAP), Oak Ridge National Laboratory

2003-present, Co-Director of Carnegie/DOE Alliance Center (CDAC)

2001-present, Visiting Professor, Department of Geophysical Sciences and James Franck Institute, University of Chicago

1999-present, Technical Review Committee (TRC) Member for H-Division (Physics), Lawrence Livermore National Laboratory

Republic of China (Taiwan)

2005-present, Chair, Advisory Committee. Institute of Earth Sciences, Academia Sinica.

2003, Search Committee for Director of Institute of Earth Sciences, Academia Sinica.

2004, Review Committee for Department of Geosciences, National Taiwan University

2003, Evaluation Committee for College of Science, National Taiwan University

People's Republic of China

2007-present, Member, Scientific Ethic Committee, Ministry of Science and Technology

2006 Forum on Science Frontier and China's Opportunities in the 21st Century, National Science Foundation of China, Beijing.

2006 Chair, International Organizing Committee, 3rd Asian Conference on High Pressure Research at Lijiang, China

2005-present, Guangbiao Chair Professor, Zhejiang University

2001-present, Honorary Director, National Research Center for High Pressure, Jilin Univ.

Named Lectures (selected):

Balzan Distinguished Lecture at Institut de Physique du Globe de Paris, University Pierre et Marie Curie and University Denis Diderot, Paris 2007

Plenary Lecture, Academia Sinica Biannual General Assembly, Taiwan 2006

Einstein Lecture, Chinese Academy of Sciences, Beijing 2005

Gregori Aminoff Lecture, Royal Swedish Academy of Sciences, Stockholm 2005;

Roebling Lecture, GSA/MSA Annual Meeting in Salt Lake City, 2005.

The 9th GRC International Frontier Lecture (4 lectures), Matsuyama, Japan 2003.

Celsius Lecture, Uppsala University, Sweden 1998

Recent Talks in UK:

Keynote talk, International Union of Crystallography HP, Oxford U., September 2007

Keynote talk, European Mineralogy & Petrology Group, Bristol 2006

Plenary talk at the UK SR Users Meeting, Rutherford Appleton Laboratory, 2006

Daresbury Laboratory Seminar, Daresbury 2002