

An Inherent Mott Transition at a Surface: $\text{Ca}_{1.9}\text{Sr}_{0.1}\text{RuO}_4$

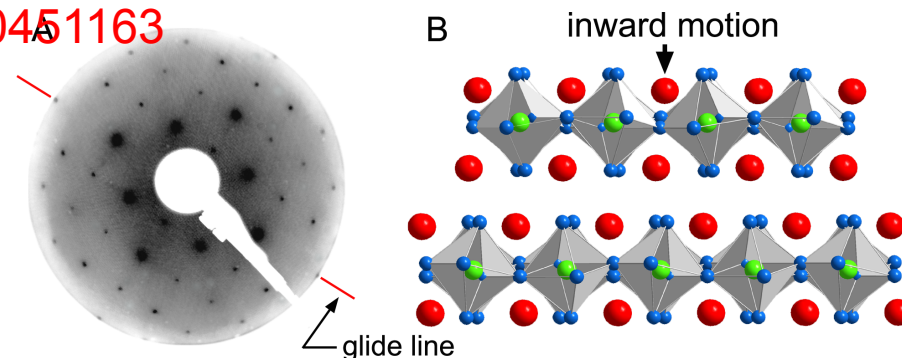
E.W. Plummer, University of Tennessee, Funded jointly by NSF and DOE(DMS&E)

Mott Transitions—metal-insulator transitions (MIT) driven by electron-electron interactions—are of fundamental importance in the physics of strongly correlated electron systems. In the layered perovskite $\text{Ca}_{1.9}\text{Sr}_{0.1}\text{RuO}_4$, a first-order Mott MIT accompanied by an abrupt lattice distortion occurs in the bulk at a temperature of $T_C = 154$ K. In contrast, at the surface, an unusual Mott MIT is observed at $T_{C,S} = 130$ K, and remarkably without a simultaneous lattice distortion. The broken symmetry at the surface causes a 150% increase in the buckling of the Ca/Sr-O surface plane stabilizing a phase more amenable to a Mott-Insulator ground state than the bulk structure. Consequently, the surface Mott MIT not coupled to any structural transition thus offering a unique opportunity to gain insight into the precise nature of an *inherent Mott transition*.

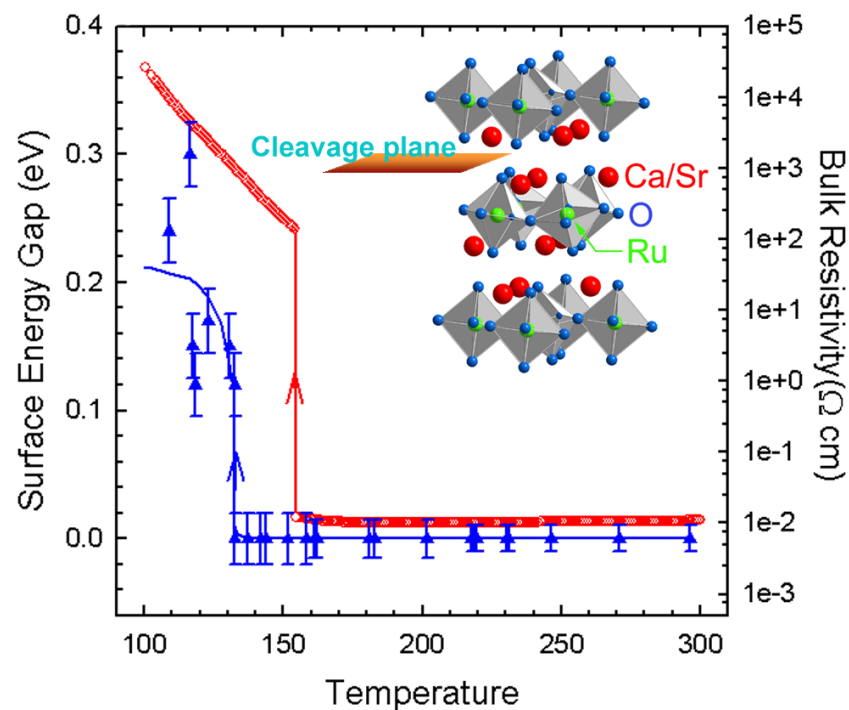
(Right) Signatures of the metal-to-insulator transition in the bulk ($T_C = 154$ K) and at the [001] surface ($T_{C,S} = 130$ K) of $\text{Ca}_{1.9}\text{Sr}_{0.1}\text{RuO}_4$ single crystal: T dependence of the bulk resistivity (○) measured using a physical property measurement system and surface energy gap (▲) measured by a scanning tunneling spectroscopy on cooling.

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(Above) A) LEED pattern from $\text{Ca}_{1.9}\text{Sr}_{0.1}\text{RuO}_4$ surface. B) Increased buckling of top most Ca/Sr-O plane by inward motion of Ca/Sr ions



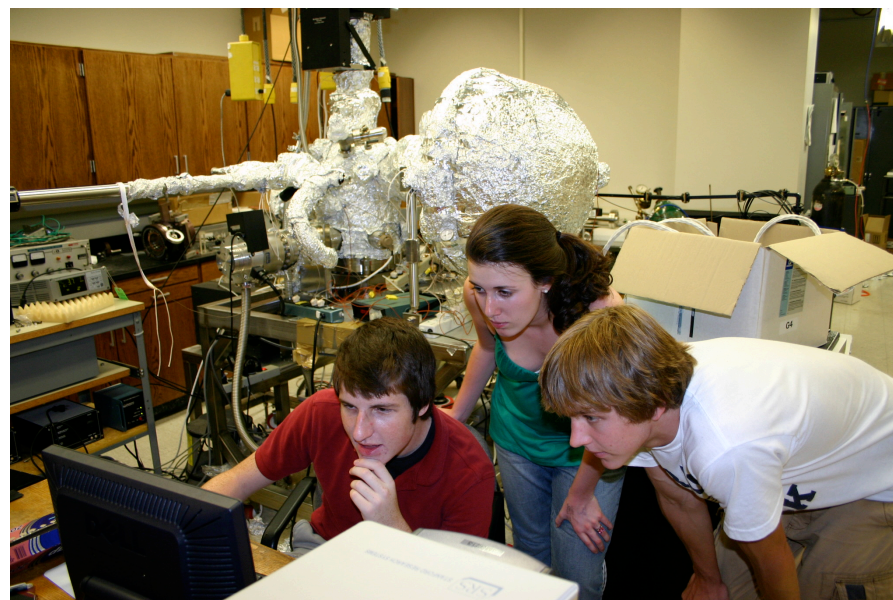
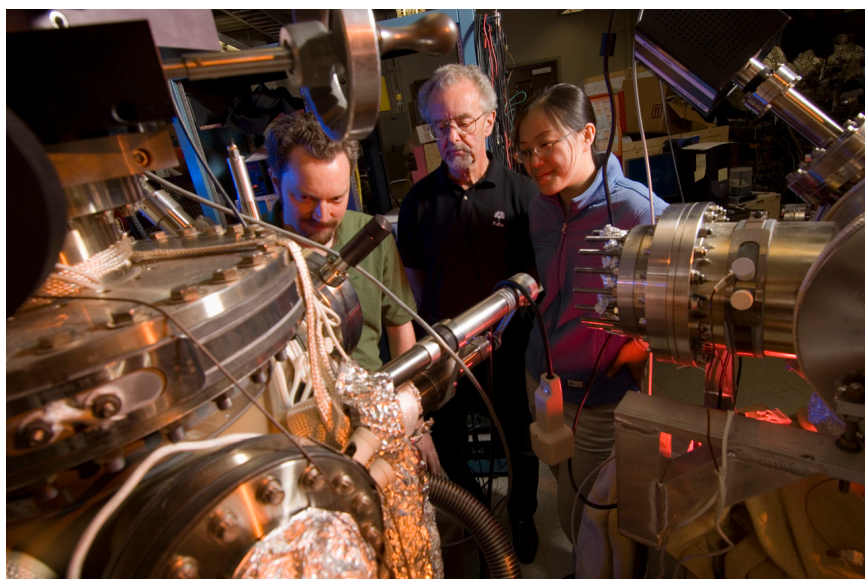
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Outreach

Continuing cutting edge research is only possible through continuing scientific education at all levels. Not only is the training of graduate students and post-docs essential but motivating high school students is imperative to the advancement of science. In addition to the graduate students and post-docs involved in various aspects of this work, high school students through sponsored summer internships have learned different aspects of surface science through hands on experience and interaction with the group.

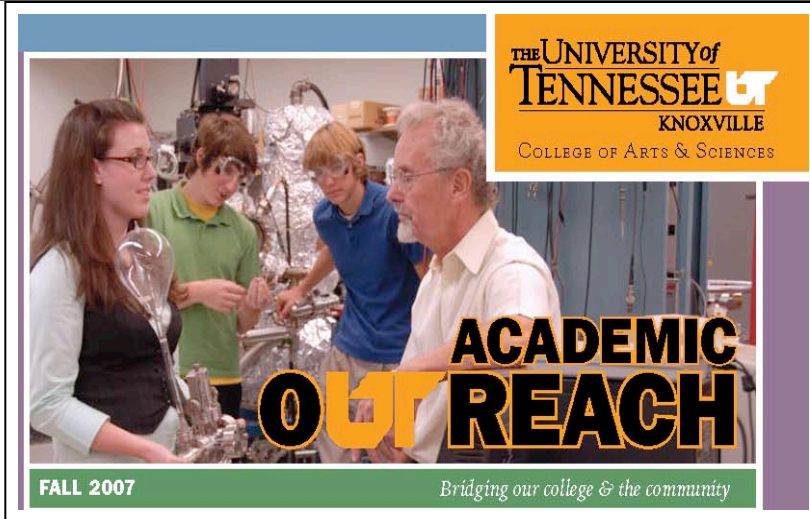


(Above) High school students from Farragut High School (TN): Kyle Peterson (left), Emma Stockdale (center), and Michael McCormick (right). Students are learning aspects of surface science and vacuum technology through direct contact with the group and active involvement in the research.

(Left) E. W. Plummer (center) with graduate student Rob Moore (left) and post-doc Hong Lu (right) interpreting LEED patterns from a $\text{Ca}_{1.9}\text{Sr}_{0.1}\text{RuO}_4$ surface.

Cultivating the Next Generation of Scientists

E. Ward Plummer (University of Tennessee), DMR-0451163 (funded jointly by NSF and DOE)



Through the Collegiate Research Scholars Program (launched Summer of 2007), top scientists from UTK are refining the talents of exceptional students from two Knox County High Schools, Farragut and Fulton. In 2007–2008, there were three Farragut students working in Plummer’s laboratory (Emma Stockdale, Michael McCormick, and Kyle Peterson) (top picture), and three new students will start this fall. All three students stated that working in the laboratory increased their interest in science careers. Emma is enrolled at Rice, Kyle at Vanderbilt, and Michael at Duke this fall.

The “Distinguished Faculty Lecture Series” was also initiated with presentations about the global energy and environmental crisis and the need for discovery of new materials in the 21st century given at the two high schools. This theme was also a showcase lecture preceding a UTK football game. The bottom picture shows Plummer giving the inaugural lecture at Farragut on November 1, 2007, to an audience of ~150 students, teachers, and parents.