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NEWS

Awards & Honors

Roald Sagdeev, Distinguished University Professor, has been elected as a member of the American Philosophical Society. Election to the Society honors extraordinary accomplishments in all fields. Founded by Benjamin Franklin, the APS has played an important role in American cultural and intellectual life for over 250 years.

William Dorland, Associate Professor, was awarded the 2008 Richard A. Ferrell Distinguished Faculty Fellowship in recognition of outstanding research and teaching.

Dr. Ferrell was a theorist with contributions in several areas, including statistical and condensed matter physics. He joined the University in 1953, and was an active member of the campus and the nearby community until his death in 2005. He is remembered for his leadership, commitment and versatility in years of great growth in the field and the department. Last fall, a symposium in Strongly Interacting Systems was held in his honor at the Max Planck Institute in Dresden, attracting many physicists with profound gratitude for Dr. Ferrell's outstanding research and teaching.

Dennis Papadopoulos, Professor, will be honored with a professional conference in his name next year. The June 2009 conference, on "Modern Challenges in Nonlinear Plasma Physics," will be held at the Sani Resort, Halkidiki, Greece, June 15-19 2009 to honor his career.

Paul Cassak, Alumnus, was awarded the F. L. Scarf dissertation award for the Space Physics and Aeronomy Section of the American Geophysical Union.

In the News

Elizabeth Lockner, Research Graduate Assistant, was interviewed for a piece on LHC that appeared on *Current TV Online.* To view the clip, visit: http://current.com/items/89294977_large_hadron_collider

William Dorland, Professor, was mentioned in the August edition of *Animation Magazine,* in an article regarding his participation in the NVIDIA CUDA conference.
To view the article, visit:
http://www.animationmagazine.net/article/8792

Dan Lathrop, Professor & Director, was featured in the September Issue of Popular Mechanics discussing research on the Earth's magnetic field. To view the article, visit:
http://www.popularmechanics.com/science/extreme_machines/4277476.html

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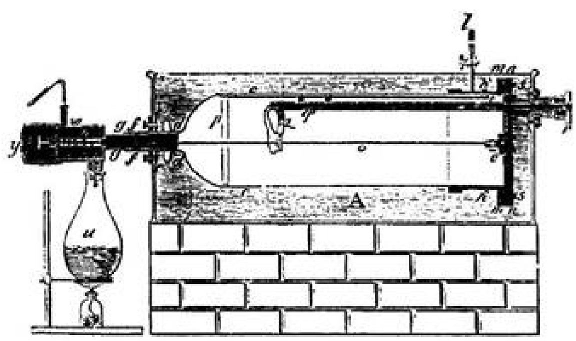
RESEARCH SPOTLIGHT

Heavy electrons: new ways to break old rules
By: Johnpierre Paglione

In 1853, well before the discovery of the electron by J. J. Thomson in 1897, two German physicists named Gustav Wiedemann and Rudol Franz made the peculiar observation that the ratio of electrical to thermal conductivities is the same in several different metals. Although not a famous as the discovery of superconductivity in mercury by Kamerlingh Onnes over fifty years afterward in 1911, this experiment marked on of the first quantitative studies of the inner nature of metals and would turn out to play a pivotal role in guiding the development of the quantur theory of solids. Much effort went into explaining "the law of Wiedemann and Franz", with the first successful (although fortuitous[i]) theoretica explanation given by Drude in 1900 in terms of a classical gas of electrons. The advent of quantum mechanics played a crucial role i advancing this interpretation, leading to corrections by Sommerfeld and Bloch in 1928 employing the concept of a Fermi gas of particles tha obey quantum mechanical statistics.

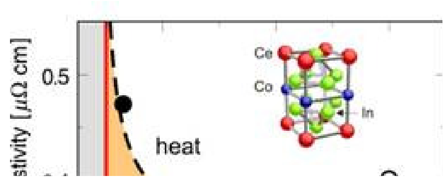
While the non-interacting quantum gas picture was quite successful, it was still not obvious how the interactions between ~10^{23} electrons confined within a small chunk of metal could be completely negligible. This remained a mystery for some time, but the last piece of the puzzle, called Fermi liquid theory, was provided by L. D. Landau in 1957. This theory presented a new way of thinking about the strong interactions present in a system, introducing the notion of "dressed" electrons, or so-called "quasiparticles," that can be treated as non-interacting particles with the same quantum variables as bare electrons, but with the effects of their interactions buried within renormalized quantities such as their mass. This finally explained the law of Wiedemann and Franz as a simple consequence of having spin ½, charge '*e*' fermionic particle excitations that transport a set ratio of heat and charge quantities given only by fundamental constants.



Apparatus used by Wiedemann and Franz in 1853 to compare the electrical and thermal conductivities of several metals.

In 1975, Fermi liquid theory was put to the test with the discovery of a new class of metals which pushed the quasiparticle idea to the extreme: $CeAl_3$, the first reported "heavy-fermion" system, is one of several metals which harbor quasiparticles with effective masses approaching 1000 time that of the bare electron mass. And yet, these are well described by Landau's theory; considering this means electrons in these materials ar slowed down to the speed of sound, this is truly amazing! However, the world is not so simple – many other materials exhibit strange metalli properties that do not fit Landau's picture, and for lack of a better term are often branded as "non-Fermi liquids." For example, some heavy fermion systems on the verge of magnetism can be experimentally tuned by applying external pressures or strong magnetic fields to travers through a zero-temperature phase transition between two stable ground states. Because it occurs at absolute zero temperature, the character o such a "quantum critical point" is dictated by quantum effects rather than the thermal fluctuations that dominate normal phase transitions. Mor important, the influence of these quantum fluctuations can disrupt the formation of long-lived quasiparticles down to the lowest measure temperatures, some 10,000 degrees below where that occurs (*i.e.* the Fermi energy) in normal metals, causing electronic masses to appear t diverge toward infinity.

The question is, are these quantum fluctuations simply altering the behavior of quasiparticles in an as-yet misunderstood manner, or have we finally gone well beyond the limits of Landau's theory? Cut to the law of Wiedemann and Franz: this nice, simple description of spin ½ charge *e* particles carrying a fixed ratio of heat and charge actually



has profound implications. It turns out to be very difficult, so far impossibly so[ii], to break this relation if you start with Landau's quasiparticle as an ingredient; being individual entities, they simply carry heat as well as charge. In this light, an experimentally observed violation of thi law is considered "smoking gun" evidence for the failure of Fermi liquid theory. Recently, studies of the low-temperature heat and charg conductivities of the heavy-fermion material $CeCoIn_5$ [Tanatar *et al.*, Science 316, 1320 (2007)] have unearthed a violation of th Wiedemann-Franz law as the temperature of the system approaches absolute zero and the ground state is tuned to a quantum critical point. B turning a knob on the magnet power supply, this system can be tuned back and forth between a Fermi liquid ground state, where quasiparticle are well behaved and the Wiedemann-Franz law is obeyed, and a strange metallic state where the WF law does not hold, suggesting that th quasiparticle description has met its match.

Does this behavior mark the death of the quasiparticle and the demise of the Fermi liquid? Oddly, yes and no. It appears that Nature simpl refuses to completely abandon Landau's picture: even when tuned directly to the critical magnetic field, the observed violation in $CeCoIn_5$ onl thrives when heat and charge currents are applied along one particular direction of the tetragonal crystalline lattice, and not the other. In othe words, it is only under the most stringent conditions that the Wiedemann-Franz law can be forced to break down, making it no surprise that thi law has stood for so long. While Gustav and Rudolf may be dismayed to know their law has finally been broken, they would surely b impressed to know that it has been the law of the land for over 150 years. Now that's an experiment to remember.

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[i] Drude's published calculation, which treated electrons using classical statistics, was fortuitously wrong by a factor of two.

[ii]The WF law remains valid in several extreme theoretical limits, including that of strong disorder and up to the insulator transition.

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ALUMNI SPOTLIGHT

Q & A with Redge Mahaffey

Redge Mahaffey, BS '71, MS '73, PhD '76, graduated from UMD and wrote an auto-biographical novel about his experience here. The novel, entitled *A Higher Education*, won a Literary Award and was the basis for his movie, *Life 101*. Below, Dr. Mahaffey answers a few questions regarding his journey.

What led you to the University of Maryland?

Because I graduated from high school in the bottom half of my class (I spent most of my time reading science fiction and physics books), my choices for a quality education were limited. Fortunately, I scored well on the SATs/ACTs. Maryland was inexpensive and a quality school. At that time, you only had to graduate from a Maryland high school with a C or better and they let you in.

How would you describe your experience here?

I had a terrific time all 9 years I was at MD. Life in Calvert Hall dorm was a great experience. I wrote about it in my novel *A Higher Education*, which won a Literary Award. The novel was also the basis for my movie *Life 101*, starring Corey Haim, Ami Dolenz and Keith Coogan.

My time in graduate school was also very productive and enjoyable. I had the good fortune to pick a wonderful thesis topic and managed to produce 7 peer-reviewed publications from my thesis (including 3 Physical Review Letters). In addition, it only took me 5 years to earn my PhD, which was a relatively short time.

Where do you currently work?

I am retired (for the 2nd time), but I work as a manager of my 45 rental houses as well as a Senior Investment Consultant for Inverness Real Estate Investments of Walnut Creek California. I help everyday millionaires invest in high-quality commercial property around the country.

What does your position require?

A solid knowledge of real estate, as well as securities. I hold a Series 7 and Series 66 license, as well as a real estate license. I evaluate and recommend real estate investments to my clients.

How has your Physics degree helped you?

The math and critical thinking skills I gained at U of MD have always served me in all of my jobs. This includes doing the budget on the fly for the 5 movies I have produced, as well as working as the Executive Vice President and Treasurer of SFA, Inc, a 100+ million dollar a year defense contractor. The ability to think critically and to present the information to single clients as well as groups of clients.

Do you enjoy your career?

I have enjoyed all of my careers. Physicist, Manager of scientists and engineers, university instructor, real estate investor, movie writer, producer and director, as well as real estate investment consultant.

What was your first job out of college?

I worked as an NRC Research Associate at the Naval Research Lab doing research on intense particle beams, x-rays and lasers.

What advice would you give current students? Do you remember any problems that you faced while here?

Enjoy life. Always stay a student, i.e. continue to learn new things every day. Don't be afraid to try new things. As Mark Twain said, "show me a man who has never failed, and I'll show you a failure."