Matter, antimatter and the price of bread

Humans weren't present from the beginning of time and so cannot see how everything got started. So physicists conduct their own studies, hoping to tease clues from Nature's tiniest creations, subatomic building blocks known as quarks. Scientists at the DOE's Jefferson Lab have concluded an experiment designed to look at some of the rarest subatomic particles known to exist: K-mesons, or kaons, and a kind of hybrid known as a hyperon.

"We are studying how matter and antimatter are produced and distributed spatially," says scientist Pete Markowitz, assistant professor of physics at Florida International University. "We produce these particles, these pairs of strange quarks and strange antiquarks, and then sift through the pieces. We're interested in one particle in a billion—and it's hard to find. We're ultimately thinking backwards: How do such particles fit together? How were they created in the first place?"

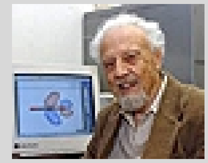
Mesons are a class of particle containing equal numbers of quarks and antiquarks (although not necessarily of the same type). When matter and identical antimatter meet, annihilation is instant and complete, with virtually complete conversion to energy. Conversely, examination of how K mesons, or kaons, are formed from energy—that is, are created—as a result of the internal interplay between their constituent quarks and antiquarks and should give invaluable insight into how quarks interact with each other.

Once a kaon is created, the remnants of its creation—particles known as hyperons, and in particular a hyperon variant called a "lambda"—are composed of one strange, one up and one down quark. Examining the structure of these particles, and the behavior of electrons emitted during multiple interactions, physicists take another step on the way to understanding how matter came to be in the macroscopic world in the first place.

"This fundamental research takes a long time to affect the price of bread in a grocery store," Markowitz contends. "But in the long run it will. It leads to a better understanding of Nature, which ultimately leads to practical benefits."

Submitted by DOE's Jefferson Lab

A GIANT AMONG US



Klaus Ruedenberg

"Among the professional options available to us we choose those that fascinate us and pose problems we feel we will be able to help solve," says Klaus Ruedenberg, an Ames Laboratory senior associate and an Iowa State University Distinguished Professor *Emeritus*.

Ruedenberg chose well in the mid 1950s when he combined his abilities in physics and chemistry to work on molecular theory, then a newly developing area of study. Today he is one of the few quantum chemists in the world to be recognized as a leader in establishing the field of theoretical chemistry and ensuring its viability during the last 50 years. Honoring his innovative research in the field, the American Chemical Society has named Ruedenberg the recipient of its prestigious Award in Theoretical Chemistry for 2002.

His work has been characterized as seminally advancing many different, important facets of quantum chemistry, encompassing fundamental theory, formal mathematical developments, computational methods and software implementations, as well as conceptual interpretations.

His elucidation of the energetic realignments that cause molecule formation has led to profound insights into the basic origin and the physical nature of the chemical bond. Related are his methods that create a rigorous quantum theoretical foundation for the 200-year-old empirical model of molecules being built from atoms, revealing the modifications of atoms by their interactions with molecular environments.

Ruedenberg's recent work addresses the problem of electron correlation, a major bottleneck in the quest for accurate quantitative predictions of the properties, in particular energies, of ground and excited electronic states of large molecules—a fundamental as well as practical goal of theoretical chemistry.

Submitted by DOE's Ames Laboratory