BROOKHAVEN NATIONAL LABORATORY

Laboratory Link

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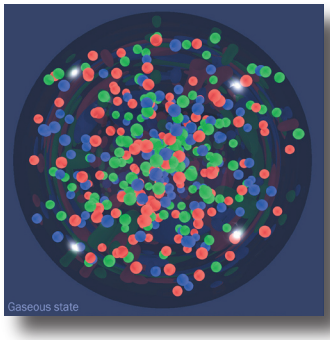
'Perfect Liquid' Discovery at RHIC Named 2005's Top Physics Story

RHIC Finding Tops American Institute of Physics' List of Science News

- As the world's newest and largest operating accelerator for nuclear physics research, the Relativistic Heavy Ion Collider at Brookhaven Lab has been colliding gold ions together since 2000. The reason: to duplicate on the atomic level the super hot and dense conditions that last existed immediately after the birth of the universe.
- At these extreme temperatures and densities, physicists expected to observe some of the most basic particles of matter — quarks and gluons — free themselves from the confines of the gold nucleus to form what is called quark-gluon plasma.
- After competing over the years to be the first to see this new state of matter, RHIC's four teams of over 1,000 physicists came to consensus last April: what existed a few microseconds after the Big Bang is not a plasma of weakly interacting quarks and gluons — it is a *liquid* of *strongly* interacting quarks and gluons!



A computer representation of the perfect liquid of strongly interacting quarks and gluons discovered at the Relativistic Heavy Ion Collider.

- Because it behaves exactly according to the rules of hydrodynamics, this is the most perfect liquid ever to have been discovered.
- This discovery made the news then—and now, since RHIC's perfect liquid was named the top physics story of 2005 by the American Institute of Physics (AIP).
- Chartered in 1931, AIP is a federation of ten member societies—including the American Physical Society, the American Association of Physics Teachers and the American Association of Physicists in Medicine—that represent scientists, educators and others within the different fields of the physical sciences.
- "This truly stunning finding at RHIC . . . gives us profound insight into the earliest moments of the universe," commented Raymond Orbach, who is Director of the Office of Science of the U.S. Department of Energy which funds RHIC operations and experiments.

BNL Chemists First to Observe Transfer of Hydrogen From Carbon to Metal

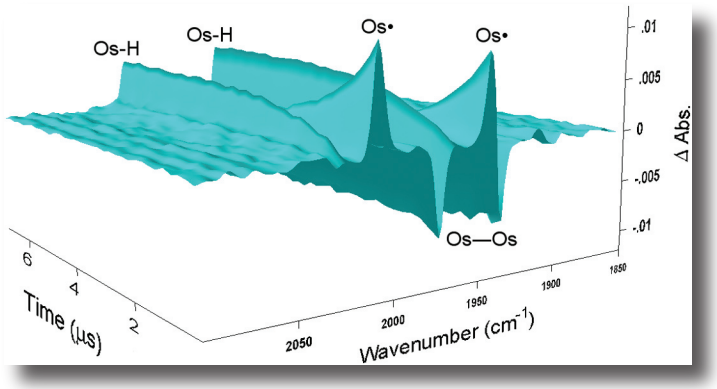
Reaction May Be Relevant to the Chemistry Involved in the Refinement of Crude Oil

- Although winter 2005-06 started at 1:35 p.m. EST on the 21st of December, the cold weather didn't wait. Just as gasoline and heating oil prices were recovering from their spike during hurricane season, the temperature dropped in November — causing most of us to raise the thermostat and increase our consumption of heating fuel. And so the weather, coupled with the forecast of a frigid winter in the northeast U.S.—the world's biggest heating-oil market—has resulted in rising world crude-oil prices.
- Gasoline, jet fuel, heating oil, diesel, lubricating oils, and asphalt all begin as unrefined petroleum, or crude oil. Pumped from below the Earth's surface, crude oil is composed of long chains of carbon atoms to which hydrogen atoms are attached.
- When shipped to refineries, crude oil is processed not only to eliminate chemical impurities, but also to "crack," or break down, the hydrocarbon chains into shorter, more useful pieces. For instance, the hydrocarbons making up gasoline are made up of shorter chains than those making up jet fuel, and so on.
- Cracking hydrocarbons is achieved, among other ways, by using relatively low temperatures and pressures in the presence of a catalyst, the majority of which assist in breaking and making carbon-to-carbon bonds, thus taking the hydrocarbon chains apart. Although most of the cracking process is done to decrease the number of carbon atoms and

(continued on reverse)

shorten the hydrocarbon chains, part of the process involves breaking and making carbon-to-hydrogen bonds.

- In research sponsored by the U.S. Department of Energy, Chemists at Brookhaven Lab recently demonstrated a new way of breaking such carbon-hydrogen bonds — by removing a hydrogen atom directly from the hydrocarbon using a chemical complex containing two atoms of the metal osmium.



A graph showing the changes in the infrared spectrum as: 1) laser light breaks the osmium-osmium (Os) bond in a complex containing two of those metal atoms, 2) a new complex containing only one osmium atom is formed, and 3) hydrogen is transferred from carbon to osmium.

- By shining laser light on the metal complex, BNL chemists were able to break the bond between the two osmium atoms. This resulted in a new, highly reactive osmium complex. Because it has a vacant bonding site, the osmium atom in this complex is then able to grab a hydrogen atom from the nearby hydrocarbon, thus breaking the carbon-hydrogen bond and forming a new osmium-hydrogen bond.
- This is the first time that scientists have, to their knowledge, unambiguously observed the movement of hydrogen atoms from carbon atoms to a metal. Although there was evidence that hydrogen atoms transfer from carbon to a metal in other reactions, this is the first time it was directly seen. The reverse reaction, whereby hydrogen moves from a metal to carbon, has been well documented.
- Now that they have shown that hydrogen atoms can be transferred from carbon to a metal, the chemists want to understand the reaction's details. "In our future studies, we want to determine the scope of the reaction," explains the experiment's leader, BNL Senior Chemist Morris Bullock. "To do this, we are asking questions such as how strong of a carbon-hydrogen bond can be broken in this type of reaction, what types of metal complexes can be used to get this reaction to occur and if the reaction does occur, how fast, etcetera."
- As Bullock concludes, "Improving our understanding of this reaction will help us evaluate the feasibility of using such reactions in practical applications" — such as cracking crude oil, perhaps.

Upcoming, Open-to-the-Public Events

at Brookhaven National Laboratory

- **SATURDAY, JANUARY 21ST, 7:30 P.M. —** The rock band Hammer of the Gods — which takes their audience back to the 1970s to recreate the look, feel, sound, and excitement of Led Zeppelin — will give a concert in **Berkner Hall, Bldg. 488.** Playing together since 2002, the band is a foursome — guitar, vocals, drums, and bass — that has been selling out shows across the Northeast.

  Tickets for the concert cost $20 per person and may be purchased in advance from www.ticketweb.com. For more information, call (631) 344-5257.

- **WEDNESDAY, JANUARY 25TH, 12 NOON —** Pianist William Chapman Nyaho will give a **free** concert in **Berkner Hall, Bldg. 488,** featuring music by composers from Africa, the Caribbean, England, and the United States.

  A native of Ghana, West Africa, Nyaho holds a bachelor's degree from Oxford University, a master's from the Eastman School of Music, and a Ph.D. from the University of Texas. He has given recitals in Europe, Africa, the Caribbean, and the U.S., including at the Kennedy Center in Washington, D.C. He has performed as soloist with orchestras across the South, been a featured performer on National Public Radio, and hosted a Bach show for Louisiana classical radio.

PLEASE NOTE: All visitors to the Laboratory ages 16 and over must bring photo ID.