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10 The Ryder Guide to the 2003 Lotus World Music Festival

Culling the world's best touring musicians from dozens of countries, the Lotus World Music Festival—celebrating this year its 10th anniversary—has become the premier Midwestern annual world cultural event. And this year Lotus reflects a bit on its history: by adding a three-venue Retro evening that revisits the first Lotus.

A five-day celebration of world music, culture and arts, this year's Lotus will present thirty acts performing in nine downtown venues, and our guide offers information about and insights into all the showcased performers.

by Seán Dwyer

22 Strings and Arrows
New Directions in Space and Time

Experiments are being carried out around the world to test a theory that, if proven, would be a startling modification of Einstein's theory of Special Relativity. A member of the team of physicists who worked with Indiana University physicist Alan Kostecke when he conceived the radical idea, examines the theory, discusses its meaning and implications, recounts the creative process, and reviews the variety of experiments that are attempting to confirm it.

One of the most promising experiments, however, must wait for the space shuttle to fly again to the International Space Station, which, as both the author and Prof. Alan Kostecke noted in a recent paper, is uniquely poised to test the theory using a cargo of atomic clocks and other precision devices.

by Neil Russell

32 Dragging the Squeegee
Poster Memories from '70s Bloomington

Between 1970 and 1978 an artist collective in Bloomington produced thousands of brightly colored silk-screened posters that featured over one hundred original designs by local artists. The posters advertised music concerts, businesses, arts and other events. In recalling those days, one of the collective's founders limns a fascinating portrait of the artists and the artform, the business and its travails, the culture and the times.

by Frank Hal

40 Shakespeare on Iraq
History Plays on the London Stage

Audiences are chuckling at a serious line in a sterling summer production of Henry V on the London stage. Don't bend the truth, Henry V advises the Archbishop of Canterbury. Funny? This summer the history plays on the stage in London have gained resonance from the crisis of state that they coincided with: the plummeting popularity of Blair, the open distrust of government claims about the justification for war in Iraq, and the controversy sparked by the death of David Kelly. In his refashioning for the stage histories of crisis and conflict, Shakespeare does not just retell history in a way consistent with Tudor ideological demands, but also dramatizes the deeper issues of the use and abuse of power, the just and unjust war, the meaning of nation.

by Tom Prasch

COVER: Art by Neil Russell and Josh Fodale. See article on New Directions in Space and Time on page 32.

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WIN CASH! ENTER TODAY!
Strings and Arrows

New Directions in Space and Time

by Neil Russell

The quest to understand Nature is shaped by experiments that produce “eureka” moments of discovery. Most experiments do not make new discoveries, but until the outcome is known, there is always an optimistic suspense. I enjoyed a moment like this because of my work with Indiana University physicist Alan Kostelecky.

Using a device called a Penning trap, University of Washington experimentalist Richard Mittleman was trying to find evidence for an idea that Kostelecky had proposed several years earlier here in Bloomington. As a member of this group at the IU Physics Department, I had contributed to the work that predicted a startling modification to Einstein’s theory of Special Relativity. Mittleman was about to present the results of one of the first experiments designed to test Kostelecky’s theory. It had the potential to turn Einstein’s theory upside down.

As an example of what the Kostelecky theory says, we may consider the proverbial Newton’s falling apple. Einstein gave us equations that tell us, for example, that the time it takes for an apple to fall a given distance is essentially the same whether it falls in the Northern or in the Southern Hemisphere. Although Newton’s much older equations of motion had also expressed this idea, they did not apply to extremely high speeds; the Newtonian equations failed when applied to speeds somewhere over a hundred million miles per hour.

The Kostelecky theory proposes another subtle change: we must take into account the direction of motion. In effect, an apple in the Northern Hemisphere could fall in slightly less time than one in the Southern Hemisphere because they are traveling in different directions as seen by someone on the Moon, say.

Just as Einstein’s beautiful theory of Special Relativity overrules the laws of Newton only under exceptional circumstances—usually involving enormous speeds or high precisions—so the Indiana theory overrules Special Relativity only in special situations, particularly ones involving directional effects. Due to the specialized nature of these effects, only the most advanced experiments would be able to detect them.

A simple way to understand the Kostelecky theory is to picture a tiny arrow at each point in space. All the arrows are parallel to each other and never change their direction. It’s as if space has a faint set of threads that run in a constant direction. As apples fall—or, more likely, microscopic particles and atoms—they cut across the arrows in directions that are, of course, different for each apple. The arrows have a stronger effect on apples that cut across them than on apples that travel parallel to them.

Since its beginnings in the 1970s, string theory has gained many proponents, and it continues to lure theorists with the promise of resolving open questions in fundamental physics.

The Kostelecky group includes more than a dozen physicists in the USA and Europe, many of whom originally trained at Indiana University as graduate students or postdoctoral researchers. The body of knowledge we have developed is now referred to in the scientific literature as the Standard-Model Extension or “SME”. The name refers, first, to the well-established Standard Model of particle physics that describes the microscopic behavior of the elementary particles, and, second, to its Extension in the form of the arrow-like concepts.

The first proposals for experiments to try to find evidence for the SME arrows were made in the mid 1990s. Mittleman belonged to a University of Washington collaboration headed by Hans Dehmelt, who shared the 1989 physics Nobel Prize for precision measurements of magnetic properties of the electron using a Penning trap. This remarkable device, capable of confining a single particle for months at a time, is also well suited to the search for the SME arrow effects.

Mittleman presented his group’s initial findings to an excited audience of about seventy physicists from six countries at the first con-

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dence on the SME, held at IU in 1998.
It turned out that the result was inconclusive,
leaving open the possibility that an improved
experiment might still find the SME arrows.
The search for the Kostelecky arrows had
only just begun.

The following year, Harvard physicist Ger-
ald Gabrielse used another Penning trap
to capture protons and other particles to look
for the effect of the arrows. Since then,
experiments aimed at measuring the space-
time arrows have been done or are being
planned by experimenta-
lists at MIT, Yale,
Stanford, Boulder, Penn State, and
Amherst as well as in Germany, Taiwan,
Australia, and France. In addition, sev-
eral large accelerator collaborations have
published results, including groups at
Fermilab in Illinois, CERN on the
France/Switzerland border, KEK in
Japan, Los Alamos National Laboratory
in New Mexico, and Brookhaven
National Laboratory on Long Island.

How can the existence of SME arrows
be proven? Can we construct a successful
experiment? To detect the filamentary
SME arrows, an experiment must be able
to point in a direction itself, like a tele-
scope. It also needs to have exceptional
sensitivity to the tiny arrow effects.

Both these requirements are met by
the atomic clock, the most accurate of
time-keepers. The heart of this sophisti-
cated device, operated by institutions
such as the National Institute for Stan-
dards and Technology (NIST) in Boul-
der, Colorado, is an enclosed cloud of
atoms, usually cesium. The atoms can be
made to jump between their quantized
energy levels, and the corresponding
radiation has an extremely stable fre-
cuency that is exploited as the ticks of

the clock, accurate enough to neither
lose nor gain a millisecond in twenty
thousand years.

The SME arrows can affect the
operation of an atomic clock
because the ticking rate would be
different when the magnetic field
is parallel to the arrows compared to
when the magnetic field cuts
across them. So if the atomic clock
with its magnetic field were slowly
rotated, the then the ticking rate,
ninety-two billion times per sec-
ond, would increase and then
decrease very slightly, once per
rotation. It would be a tiny varia-
tion, perhaps just a fraction of one
extra tick per second.

Several experiments have been
performed with clock-like devices.
These include two done with
masers at the Harvard-Smithsonian
Institute for Astrophysics by experi-
mentalist Ron Walsworth. Masers
have a

number of similarities to
to atomic clocks,
icluding a
magnetic field
allowing them
to point in
different
directions.

How does
Walsworth
rotate his masers? The answer is that the
Earth does it for him. As the Earth
rotates, the magnetic field of the maser
rotates with it. And since the arrows are
fixed in space, minute variations could in
principle be detected. Walsworth’s group
published inconclusive results from his
first experiments in 2000 and is cur-
tently working on further refinements.

The challenge facing Walsworth
and other experimentalists is the attainment
of unprecedented precisions. Without
exceptional sensitivity, the unthinkable
small effects cannot be detected. Finding
a minuscule effect in any experiment is
difficult, because random effects,
“noise,” create fuzziness in the data. The
problem is how to distinguish the effect,
or “signal,” due to the arrows, from the
unwanted noise that masks it. In general,
Sources of noise include random changes
in the laboratory environment: tempera-
ture or pressure variations, vibrations,
and so on. A good experiment needs to
be insensitive to the noise and highly
sensitive to the signal. In short, it needs
an exceptionally high “signal to noise
ratio.”

The first line of attack to improve the
signal-to-noise ratio is to fine tune the
experiment. This would mean finding
improved ways to keep temperatures,
pressures, or other environmental factors
constant. However, the gains from such
refinements are limited. Ultimately, the
best option is to design a more cunning
experiment, with an intrinsically higher
signal-to-noise ratio.

Last summer, collaborators Robert
Bluhm, Chuck Lane, and I published a
paper with Alan Kostelecky in which we
pointed out that atomic clocks and other
precision devices planned for
flight on the
International
Space Station
would be
uniquely
poised to find
the SME
arrows. Atomi-
clocks on

the Space Station could in principle be
about ten times more precise than ones
on Earth. They would exploit the
weightless environment, which allows
the atoms to float freely for a significant
period of time while their energy transi-
tions are measured.

We have found that there appear to be
two other advantages to space-based
experiments. One is the great speed of
the Space Station, about twenty thou-
sand miles per hour. This might make it
possible to detect some of the relativistic
aspects of the arrows. The other advan-
tage is related to the much greater rota-
tion rate of the Station, once every nine-
ty minutes, compared to about once
every twenty-

Atomic clocks, which are accurate
enough to neither lose nor gain a
millisecond in twenty thousand
years, would be uniquely poised
aboard International Space Station
to find the SME arrows.
four hours on the Earth.

Two groups based in the USA are busy designing and building atomic clocks for the International Space Station. The Primary Atomic Reference Clock in Space (PARCS) group, based at the University of Colorado and NIST in Boulder, is building a new cesium atomic clock. Another group is building the Rubidium Atomic Clock Experiment (RACE) at Pennsylvania State University. While standard atomic clocks work with cesium atoms, this one would exploit technological advantages with rubidium atoms to gain improved frequency stability. Both of these experiments have NASA support and may be seen in orbit within a few years.

The European Space Agency (ESA), a partner with NASA, also has a group working on atomic clock technology for the International Space Station. Their Atomic Clock Ensemble in Space (ACES) apparatus will consist of a maser and at least one cesium clock. Both the NASA and the ESA experiments will be able to look for the Kostelecky arrows.

Searches for the filamentary space arrows are not limited to Penning traps and atomic clocks. Over the last six or seven years, about twenty experiments have attempted to seek them out. They include accelerator-based experiments with kaons, D mesons, B mesons, and muons; they include work done with the exotic atom called muonium, in which the nucleus of a hydrogen atom is replaced with a positively-charged muon (much like a heavy electron); they include experiments done with a pendulum that twists instead of swings—a torsion pendulum; and they include results obtained from analysis of light from distant cosmic sources. So far, none of the experiments has been able to discern a definite signal of the arrows from the background noise. A number of the results were presented at a second meeting dedicated to the SME theory held in Bloomington in the summer of 2001.

For physicists, the importance of the SME is its implications for the "Holy Grail" of physics, the ultimate unified theory combining the general theory of relativity and the theory of quantum mechanics. Einstein himself spent much of his later life in an unsuccessful search for such a unified theory. It is possible that the SME could be a key to finding it. While the SME arrows may be too minuscule to discern with present technology, it is possible that they played a role in the early universe, just moments after the Big Bang. Thus, high-precision experiments in space could resolve an important question. Indeed, on a cloudless night a few years from now, we may be able to look into the sky above the fish on the Monroe County courthouse and follow the bright path of the International Space Station on the quest for an idea first proposed just a few blocks away, at the other end of Kirkwood Street.

Neil Russell is a faculty member in the Physics Department at Northern Michigan University in Marquette, Michigan. His recent research includes proposals to verify the Standard-Model Extension using experiments on the International Space Station. He visits Bloomington periodically to pursue this work.