UCLA Team Seeking New Keys to Atoms’ Inner Secrets

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Chan Joshi neatly navigated the labyrinth of Boelter Hall, heading toward his laboratory on the first floor of the UCLA engineering building. The cluttered, windowless room was dominated by a carbon-dioxide laser and odd paraphernalia such as skull-like copper mirrors and part holes sliced from pure salt crystals.

Off in one corner was a stainless steel chamber the size of a vacuum cleaner. Joshi and his graduate-student assistants peered inside. This is where they taught electrons to surf.

In Texas, workers only recently began constructing the Superconducting Super Collider, and years will pass before the

UCLA professor Chan Joshi shows functions of a new type of particle accelerator. 64-mile-long, $10-billion device can be switched on to try to answer some fundamental questions about atoms and the universe.

But Joshi and a handful of other scientists already are looking beyond the SSC and asking: What next? Like superior chess players, these scientists are scrambling to stay several steps ahead of themselves. Their goal is to anticipate the methods and machines that will be needed to solve subatomic riddles no one has yet uncovered—riddles with solutions beyond the reach even of the mighty SSC collider.

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biggest and longest scientific de

very in history.

In an experimental laboratory, Joshi

has demonstrated the feasibility of

over these machines, a new kind of

particle accelerator. Unlike the

super collider, which uses elec-

trical fields to crack open relatively

heavy protons, Joshi’s device uses

plasma waves to slam together

lighter electrons.

H

is “beast-wave accelerator,”

based on a theory by fellow

UCLA professor John Dawson, ex-

ploiting exquisitely fast laser pulses

lasting just a few billionths of a second

to push electrons almost to the speed

of light in a fraction of the space

required by today’s best particle

accelerators.

With this technology, better

particle accelerators would not

necessarily have to be bigger. That

is welcome news to policymakers

still trying to sell a skeptical Con-

gress on the value of completing

a new large collider, under the size of an

county.

The laser pulses in Joshi’s device

can create an essentially agitated gas

or plasma, ripping with very low

density waves. Electronically added or

precisely the right instant tend to “melt”

in these waves, picking up speed

very rapidly.

It is a delicate and complicated

process that relies on notoriously

unstable plasmas, Joshi conceded.

But the experimental machine in

his laboratory, while capable enough to be worthy of Notre

Goldberg, shows that the idea

works—indeed, he said, “it worked

just as advertised.”

And, Joshi added, the “beast-wave

accelerator has the ability to speed

up electrons more quickly than any

other device, as a production model

eventually may reach the power

of some of today’s most powerful

accelerators in a fraction of the

space.

Whether this technology ever

leaves the lab depends on whether

Joshi and other researchers—beast-

wave accelerators also are being

developed in Japan, France and

Britain—can increase both the size

and power of their machines at a

reasonable cost.

For now, they prove unable to

do the kind of cutting-edge re-

search expected of the super collid-

er, beast-wave machines still can be

useful, Joshi and Dawson said. The

relatively compact devices would

be easier to fit on college campuses,
making them more accessible.

Instead of one giant machine

accommodating a few collaborative

experiments—a process that forces

many scientists to compromise

desires—dozens of machines could

let individual researchers pursue

their own theories. Accelerator
time could be as accessible

as computer time became when

personal computers supplanted

bulky mainframes.

In addition to benefiting re-

searchers, powerful accelerators

could be accessible to more

hospitals, where cells killing

tumors are a few of a second

to combat cancer. “Best-wave

machines also can be used to
generate very short bursts of X-rays

that would permit better medical

images using only a fraction of the

radiation.

These electromagnetic “micro-

bursts” also could allow scientists
to make slow-motion movies of

chemical reactions, which have

never been seen before.

None of this occurred to Dawson

when he dreamed up the idea of

best-wave particle accelerators

while working at Princeton Uni-

versity in the 1970s. At the time, he

was trying to use the coherent

amplified light in laser beams to

trigger temporary nuclear fusion

reactions, but was frustrated when

the laser created turbulence in the

reactor’s plasma fuel.

Once he worked out how the

turbulence could be harnessed
to accelerate electrons, potential

applications were easy to think up,

he said.

Accelerator physicist Andrew

Sotner of Lawrence Berkeley

Laboratory said the demomstrations

by Joshi was “a significant step

forward” in efforts to develop a

new generation of accelerators.

When the super collider eventually

uses its unprecedented energy to

crash protons, the debris should

tell physicists a lot about atoms

what holds them together, what

causes some to decay radioactively,

and how those processes are relat-

ted.

But the field of particle physics

will not come to an end when the

super collider completes its work,
even if its pace helps scientists

map out the grand-unification

theory—the so-called “theory of

everything” that would prove a

common basis for all the basic

forces in nature. Achieving this,

which stimulated Stratos, is the

most holy pursued goal in physics.

Scientists have learned that
discovery made by the SSC now

likely to raise a new set of ques-

tions.

When the Greeks, for example,

first tried 2,400 years ago to divide

the most basic building blocks of

nature, they suggested that matter

was made of indivisible particles

called atoms.

Savvior scientists later asked

what those atoms were made of, and

then asked the same question about

the protons, neutrons and elec-

trons Joshi found. This led to the
discovery of exotic new particles

called leptons and quarks, as well as

beams, pi-mesons and other parti-

cles binding them together.

At each step, discovery of new

“elemental” particles led to a

fuller understanding of nature and

significant advances in electronics,

chemistry and the development of

new plastics, metals and other

materials.

Some of the particles described

in the “standard model” of atomic

structure exist only on paper

because no one has a machine

powerful enough to thoroughly

smash protons and find them. No one, for

example, has confirmed the exis-

tence of the “top quark” (an

arbitrary name chosen by whistling

physicists) or the “Higgs boson”

tipped off a British physicist).