



FILM CORPORATION

NEWS FOR SCIENCE EDITORS:

" MOVING THROUGH MATTER "

WITH

BUCKAROO BANZAI

by

Dr. Cary I. Sneider

This month's (August) release of the motion picture, " The Adventures of Buckaroo Banzai," presenting a particle physicist as its hero, is expected to stimulate interest and questions from the public on the scientific subjects explored in the film. This article addresses those subjects. It is printed here for your information and for any use you might wish to make of it.

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MOVING THROUGH MATTER

"Buckaroo Banzai" Creates a New Dimension in Science Fiction

by

Dr. Cary I. Sneider

When scientific methods and theories are imaginatively, yet plausibly portrayed in a science fiction film, the result is not only entertaining for the audience, but can be equally stimulating for the scientist.

This is the case with "The Adventures of Buckaroo Banzai," a science fiction film scheduled for release this August.

In a key scene from the film, Buckaroo pilots a jet car which spews a twenty-foot sheet of flame in its wake. Accelerating to 700 miles per hour, he heads straight for the face of a mountain. Just before impact, he switches on the "Oscillation Overthruster" and passes through matter into the eighth dimension.

This gripping scene from Earl Mac Rauch's screenplay may seem like just another science fiction adventure. But there is something unusual about this film that speaks to the scientist in me and to my curiosity about space, time, and matter. It also struck a responsive chord in a colleague of mine, Dr. Joseph Bisognano, who is a particle physicist with a specialty in designing accelerators. Many of the following ideas about the science in "Buckaroo Banzai" grew out of a long discussion we recently had together.

What Joe and I like most about the film is that it presents flights of fantasy that are grounded in scientific principles, and does not follow the common practice of portraying a great scientific breakthrough as a lucky accident in the lab. The machine which finally enables Buckaroo Banzai to move through matter is based on decades of research that are shown to the audience through home movies and flashbacks.

It is very easy, almost seductive, for science fiction screenwriters to coin a term for a marvelous new process, and wrap it in a black box with lots of tubes, dials and meters. But calling something a "gizmo" doesn't begin to help the audience understand science. As incredible as an Oscillation Overthruster may seem to be, it's not just another gizmo; it's a colliding beam particle accelerator that fires intermediate vector bosons. This is not just gibberish that audiences come across in most science fiction films, but an important concept introduced by Buckaroo Banzai. Banzai has hit upon the notion that such a machine may exploit the fact that matter is almost entirely empty space, and that if he could somehow change the forces that hold matter together, it would be possible to move through it.

Not only does Buckaroo Banzai help people understand principles of matter, he adds new dimensions to the general public's understanding of space and time. Because when Buckaroo Banzai goes through matter, he doesn't just get to the other side -- he winds up in the eighth dimension! As we'll see, even this idea has some basis in scientific theories dealing with the geometry of space.

The line of investigation which led to the Oscillation Overthruster began with an experiment in 1938 that was conducted by Buckaroo's father, Masado Banzai, and two colleagues: Emilio

Lazardo and Toichi Hikita. The late 1930s was, in fact, an exciting period for physicists. Particle accelerators were beginning to bloom with the invention of the cyclotron by Ernest O. Lawrence, and physicists such as Hideki Yukawa (who could have been a colleague of Toichi Hikita, senior scientist in the film) were developing quantum field theory to describe the nature of matter and the forces that bind it together. Unlike Tom Swift, who could throw together one major invention a night, Buckaroo Banzai's struggle to find a path through matter was based on decades of research and experimentation that coincided with actual developments in science.

The idea of moving matter through matter is not, of course, a new one for science fiction films. The trick was also accomplished by the star of "The 4-D Man," who failed to provide a reasonable rationale for the process he used to move through matter. In contrast, Buckaroo demystifies this intriguing concept with a simple, accurate description of the structure of matter that could have come out of the mouth of Mr. Wizard:

BUCKAROO

See this glass. It's solid matter, right? But in point of fact, the solid parts of this glass -- the protons, quarks, your neutrons and electrons -- they comprise only one quadrillionth of its total volume.

Buckaroo is right in saying that subatomic particles take up only one quadrillionth of an atom's total volume, like a bee in the middle of St. Peter's Cathedral. But we can't just pass our hands through glasses or other solid matter. What fills up the empty space within the atoms? We all learned in school that atoms hold themselves together because protons in the center (nucleus) have

a positive electric charge which attracts the negatively charged electrons which fly around the outside of the atom. This force, which acts between the electrons and protons is called the "electromagnetic force." You can feel the electromagnetic force when you use a magnet, or when you slap your hand against a wall. But you may not have asked yourself how the electrons and protons "feel" each other across the empty space that separates them.

According to quantum field theory, as initially developed by Yukawa and many others in the 1930s (when Buckaroo's father first began his experiments), the forces between particles are created by exchanges of other particles. The electromagnetic force is carried by the exchange of particles called "virtual photons." In other words, the empty space between the electrons and protons in normal material is full of virtual photons. Furthermore, if virtual photons fail to travel all the way between electrons and the nucleus, atoms would no longer be prevented from passing through each other.

The basic premise of the Overthruster seems perfectly reasonable if we could just find a way to do this. How could we shorten the distance that virtual photons travel within the atom? Since virtual photons have no mass, they are able to travel the full distance between electrons and protons. What would happen if the virtual photons were given mass? If virtual photons had mass, they would be restricted to a very small region around the elementary particles that make up the atoms. This would reduce the ability of these particles to "see" each other, in effect creating truly empty space within and between atoms. The passage would be clear for Buckaroo Banzai and his jet car to pass through matter. How does the Oscillation Overthruster increase the mass of virtual

photons inside matter? Let's take another look at the script for a clue.

PROFESSOR HIKITA

Let me ask you to imagine the Oscillation Overthruster as a sophisticated rifle accelerator.

RENO

Firing a steady stream of intermediate vector bosons at a target -- in this case a mountain.

It was no mistake that "intermediate vector bosons" were selected by the writers. Recently, Weinberg, Glashow and Salam developed a theory of the "electroweak" force which is carried by four kinds of particles: three kinds of intermediate vector bosons (the W^+ , W^- and Z^0) and virtual photons. These particles are, in some sense, alike. In fact, all four start out with no mass. By the poorly understood mechanism of "spontaneous symmetry breaking" the intermediate vector bosons take on mass, and become carriers of very short range (weak) forces. In fact, the range of the weak force is so short that a neutrino, which only interacts weakly, can pass through the entire earth without interacting with a single atom.

"Spontaneous symmetry breaking" is a stopgap measure, a particle theorist's trick which someday will be replaced by a more fundamental notion. Because this aspect of the theory is still developing, it is not unreasonable to speculate that a high energy beam of intermediate vector bosons, directed at solid matter, might impart mass to the virtual photons that keep its atoms from passing through each other. In the words of Professor Hikita in the film: "The oscillation overthruster is a rather small colliding beam accelerator, if you will, a crude 'contraption' whose purpose was simply to enhance the electroweak forces that pertain between

subatomic particles, thus making those forces the most powerful events occurring within a molecule." (from Buckaroo Banzai: A Few Facts and Some Persistent Rumors by the film's director, W.D. "Rick" Richter).

Hikita's statement uses the term "electroweak," which is of fairly recent vintage. While this is not an anachronism since it comes from a recent interview with the Professor, we wonder about the 1938 experiment. How could it have been anticipated that the electromagnetic and weak forces would someday be united? For the principle of the Overthruster to be conceived, that was not necessary. In the 1930s physicists were already developing quantum field theory, and it would have been apparent to a physicist such as Hikita that if the photon could be given mass, it might allow one to pass through matter. The failure of the early experiments might even be traced to the selection of an inefficient beam particle, since the intermediate vector boson was not yet suspected.

As the Professor explains, the Overthruster is a device "which systematically reorders matter by annihilating electrons and positrons." It consists of two colliding beams, one of electrons, and one of positrons, which annihilate each other when they collide. Each annihilation produces a burst of particles, including intermediate vector bosons. These are separated and focused into a beam by powerful magnets. Consistent with Professor Hikita's statement, the antiparticle of the electron, the positron, was discovered in 1932.

But the Overthruster is tiny. Buckaroo Banzai's ability to miniaturize sophisticated equipment has vastly improved on methods used by today's scientists to produce intermediate vector bosons.

In contrast, the colliding accelerator at CERN in Switzerland, which produces a scant quantity of intermediate vector bosons, is many kilometers in circumference. Damn the orders of magnitude, and full steam ahead! Buckaroo Banzai's Overthruster makes up for what it lacks in size with superconducting magnets and laser acceleration. Both of these concepts are at least rooted in today's research and development programs for particle accelerators.

Now that we've covered the theoretical bases, let's take Buckaroo's invention for a spin and see how it works. First, the Overthruster produces colliding beams of electrons and positrons. These, in turn, produce copious quantities of intermediate vector bosons which are separated and focused with superconducting magnets. When focused on solid matter, the beam produces a small region of high energy density. Inside the target, spontaneous symmetry breaking imparts mass to the photons, reducing the range of the electromagnetic force to far less than a quadrillionth of a centimeter. From this small region a shock wave of broken symmetry propagates outward. Behind the shock wave matter interacts only weakly, providing for Buckaroo and his jet car to move through matter. The car must travel very fast (at least 700 miles per hour) to allow free passage before the material reverts to its normal state.

If you can imagine this journey through matter in Buckaroo's jet car, you're almost there. But where is "there?" Buckaroo's destination is not the fourth or even the fifth, but the eighth dimension! Where in hell is the eighth dimension?

The world of our everyday existence is known as "Minkowski spacetime." It has four dimensions, three spatial dimensions

and a time dimension. When we deal with very large objects, it is essential to take into account the curvature of space which plays an important role in Einstein's special theory of relativity. At the human scale space doesn't look curved, but astronomers, who work at the galactic and supergalactic scale, must take the curvature of space into account.

In 1921, Theodore Kaluza, and later Oskar Klein, speculated that there may be mini-dimensions to space that we do not perceive. Here we are working in the realm of the very small, so we need to consider the geometry of space at a scale that is even smaller than the nucleus of an atom.

Dimensions are usually diagrammed as infinitesimally thin, mutually perpendicular lines. In the Kaluza-Klein theory, these lines become cylinders with a radius much less than that of an atomic nucleus. In other words, each dimension of spacetime is in fact two-dimensional: a cylinder of finite radius but infinite length. There would then be a total of eight dimensions, in which the eighth dimension is the sister dimension of everyday time, but at the subnuclear level.

Why can't we perceive all eight dimensions like Buckaroo Banzai? Because when we move along a mini-dimension, we are moving around the perimeter of the cylinder, which instantaneously leads us back to where we started. In other words, we move through eight dimensions all the time, but we just don't know we've made the trip because it was so short! Therefore, we don't have time to perceive it.

When Buckaroo is moving through the mountain, he is permeated with an electromagnetic force that is acting at an extremely small, subnuclear range. With a little effort, we can imagine that would

allow Buckaroo Banzai to experience these four additional mini-dimensions which are hypothesized to exist at the same subnuclear scale.

When Buckaroo Banzai travels through matter he discovers a parallel world in the eighth dimension that is inhabited by bizarre creatures called Lectroids. The world of the Lectroids opens new vistas to stimulate filmgoers' interests. Take, for example, the evolution of Lectroids and their organically grown spaceships on the tenth planet of the solar system, or their passion for electrical discharges. (The Lectroids passion for electrical discharges leads some of them to plug themselves into 110 volt A.C. outlets. Obviously, this is something that no human should ever attempt.)

An attribute of good science fiction, I think, is a core of ideas that invite the reader to entertain possibilities beyond those expressed in the film. One wonders, for instance, if the plane of existence discovered by Buckaroo Banzai is the only one besides our own? Scientists have already hypothesized worlds with more than eight dimensions. Bruce DeWitt (Scientific American, December 1983, p. 129) comments: "In the 'super' Kaluza-Klein model that is currently most popular, seven extra dimensions are added to spacetime. These dimensions have the topology of a 7-sphere, a space which has some fascinating properties of its own." This theory offers interesting possibilities for Buckaroo's sequel writers.

As outlandish and entertaining as it is on one level, "Buckaroo Banzai" creates a place for the process and content of science in the science fiction film. Not only does this film challenge our imagination as moviegoers, it challenges other filmmakers to throw away their sorcery, and base their fantasies on a reasonable portrayal of the way that scientists actually work. The most important

contribution of "Buckaroo Banzai" is to demonstrate that there is a very important role for imaginative science to play in imaginative science fiction.