Bahaa E. A. Saleh (June, page 26).

The coherent state localized at $\langle x\rangle$ and $\langle p\rangle$ is properly described by the (normalized) wavefunction

$$\psi(x) = (2/\pi)^{1/4}\ \exp(2i\langle p\rangle x) \times \exp[-(x-\langle x\rangle)^2]$$

When this wavefunction is inserted into the Wigner phase-space distribution function, defined as

$$W(x,p) = \frac{1}{\pi}\int \psi^*(x+\frac{1}{2}y)\,\psi(x-\frac{1}{2}y)\exp(2ipy)\,dy$$

the result given by Teich and Saleh is obtained, namely

$$W(x,p) = (2/\pi)\exp[-2(x-\langle x\rangle)^2] \times \exp[-2(p-\langle p\rangle)^2]$$

It is easily shown that the above definition of $W(x,p)$ properly yields $|\psi(x)|^2$ when integrated with respect to p, and $|\varphi(p)|^2$ when integrated with respect to x. The "momentum" wavefunction corresponding to $\psi(x)$ is defined here by

$$\varphi(p) = \left(\frac{1}{\pi}\right)^{1/2}\int \exp(-2ipx)\,\psi(x)\,dx$$

The extra factors of 2 that appear in the above formulas can be traced back to the commutation rule $[\hat{x},\hat{p}] = i/2$, from which it follows that an appropriate representation of the "momentum" operator is $\hat{p} = (i/2)\,\partial/\partial x$, and the wavefunction of a momentum eigenstate with momentum p is

$$\psi_p(x) = (1/\pi)^{1/2}\ \exp(2ipx)$$

JOHN PHILPOTT
Florida State University
Tallahassee, Florida
6/90

TEICH AND SALEH REPLY: The definition of the Wigner distribution function used in our article should indeed be modified, as John Philpott points out. The results presented in the article are not affected by this error, however.

MALVIN C. TEICH
Columbia University
New York, New York
BAHAA E. A. SALEH
University of Wisconsin
Madison, Wisconsin
9/90

Angular Momentum Quantization Qualm

In his news story about "anyons" (November 1989, page 17) Anil Khurana apparently makes the *general* statement that angular momentum is not quantized in two spatial dimensions. In the *absence* of electromagnetic fields like flux lines, I find this hard to reconcile with the superposition principle and the probability interpretation of quantum mechanics. If one writes the wavefunction of a single spinless particle in polar coordinates ρ and φ, an arbitrary normalizable function $f(\rho)$ is an eigenfunction with angular momentum zero, while $f(\rho)\exp(im\varphi)$ has angular momentum $\hbar m$. If one considers a linear superposition of the two wavefunctions, the corresponding probability density is given by $2|f(\rho)|^2[1+\cos(m\varphi)]$. As probabilities should be single-valued, the quantization of angular momentum follows without invoking the single-valued-ness of the wavefunction as the starting point. This argument holds in two as well in higher spatial dimensions. The reasoning given for the quantization of angular momentum in integer units for "normal" (non-fractional-statistic) particles shows that the description of anyons has to involve a superselection rule for states of different orbital angular momentum.

K. SCHÖNHAMMER
Institut für Theoretische Physik
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Göttingen, FRG
1/90

'Doc' Draper Praised; A-Bomb Reappraised

It is unfortunate that Brian Reid (December 1989, page 101) was troubled by the fact that the National Academy of Engineering decided to name an award honoring engineers and technologists for "contributing to the advancement of human welfare and freedom" after Charles Stark Draper. It is even more unfortunate that Reid did not know "Doc" Draper.

The Charles Stark Draper Prize was established and endowed at the request of the Draper Laboratory because we think it a fitting tribute to Doc's memory and his contributions to engineering and technology. We intend that the prize will focus world attention on the important work of engineers in the same way that the Nobel Prize now focuses attention on accomplishments of scientists.

It is perhaps tragic that Reid does not recognize the contributions to "the advancement of human welfare and freedom" of technologically superior weapons developed to deter war. One of the important lessons of history is that the scourge of war is most likely to occur if free nations are *not* adequately prepared for it. We at Draper Laboratory are proud of our contributions to national defense and consider that work among the most noble in the engineering profession. So did Doc Draper.

It is also unfortunate that Reid apparently does not recognize how useful some engineering achievements initially developed for defense have been for society at large. Mechanical heart valves, silicon carbide ceramics, Mylar, flameproof epoxy paint, cordless tools, graphite composite materials, self-contained breathing apparatus, freeze-dried food, microwave technology, nuclear power, pacemakers, helicopters, electric analog computers and nuclear medicine are just some examples.

Ironically, Reid feels the Greek mathematician, physicist and inventor Archimedes would be a much worthier person for the academy to name a prize after. I say "ironically" because while Archimedes made original contributions in geometry and mathematics and founded the fields of statics, hydrostatics and mathematical physics, he also invented mechanical devices useful both in peace and in war and the defense of his society—just as Doc did.

In 214 BC, when Archimedes's native city of Syracuse was besieged by the Roman general Marcus Claudius Marcellus, the defense of the city was aided by military machines designed by Archimedes—including catapults, missile throwers and grappling hooks (*Encyclopedia Americana*, 1986). Legend has it Archimedes also devised concave mirrors that burned Roman ships by concentrating the Sun's rays on them.

Thus Archimedes made significant contributions to the advancement of human welfare and freedom, at least from the perspective of the Greeks, as Doc Draper did through his numerous engineering developments for his own nation. The achievements of both men had far-reaching effects on all aspects of their respective societies. I think Doc would be quite pleased with the parallel, and to be in such rich company.

RALPH H. JACOBSON
Charles Stark Draper Laboratory
Cambridge, Massachusetts
1/90

Contrary to Brian Reid, I feel that the citation "contributing to the advancement of human welfare and freedom" precisely describes the career of my late friend Charles Stark Draper.

Most of today's airline passengers are guided to their destinations by his Inertial Navigation System, which also took the Apollo astronauts to the Moon. As the NASA history reports, Charlie volunteered to operate it himself if the astronauts couldn't be taught to do so!

The last time we met—here in Sri

Lanka when he was on his way to China—Charlie told me that one of his proudest achievements was the number of American lives and ships his radar antiaircraft-gun control had saved by virtually eliminating the kamikaze menace.

I would also point out that Reid's choice of Archimedes versus Draper is singularly inept. Archimedes was as famous in antiquity for his engines of war as for his mathematical achievements—and of course, pioneered directed-energy weapons in the defense of Syracuse.

Nevertheless, Reid's letter raises a profound question for which there are no simple answers. It is even more acute in the cases of such towering scientists as Luis Alvarez, Andrei Sakharov, J. Robert Oppenheimer, Edward Teller and Richard Feynman. I discuss the still more controversial case of another friend, Wernher von Braun, in *Astounding Days: A Science Fictional Autobiography* (Bantam, New York, 1990).

ARTHUR C. CLARKE
University of Moratuwa, Sri Lanka
1/90 and International Space University

The exchange of letters between Lawrence G. Rubin and Barton J. Bernstein (December 1989, page 100) on the history of the US decision to drop the atom bomb on Japan is an example of the different viewpoints held by veterans and others who lived through World War II and by the history revisionists who grew up later. Brian Reid's letter in the same issue (page 101) is typical of the ultrapacifists of the postwar generation who were saved by the Allied victory of the previous generation and have been protected since by the heavily armed NATO forces.

I am not a militarist and I look forward to a massive reduction of armaments everywhere in the world. In the 1930s I was sympathetic to the Oxford movement and took part in student strikes against war and the "merchants of death." I was wrong: This only encouraged Hitler and his Axis allies to further aggressions.

I sat on Iwo Jima in 1945 watching the carnage in Okinawa. The American forces lost 6000 dead and had 15 000 wounded in taking Iwo, where the Japanese lost 17 000 dead and had 5000 other casualties. Twelve thousand Americans were killed and 36 000 wounded taking Okinawa. There were over 100 000 Japanese dead. Thirty-four American ships were sunk and 368 were damaged, mostly from the suicidal kamikaze attacks, at Okinawa. The US military command did not expect such a slaughter. Each area was bombarded for weeks by naval guns and by air bombing before the assault. The Japanese had no air or naval defense.

Bernstein says honest analysts claim that there were alternatives to the invasion of the homeland and that the Japanese might have changed character and surrendered rather than fight to the death. I do not know what alternative strategies the high command had under consideration. The capture of Okinawa and the intensity of the air bombardment were of a piece with the prior campaigns of island hopping and appeared to be directed to an invasion of the mainland.

As examples of the fierce single-mindedness of the Japanese soldiers consider the number of them who never surrendered and were found, still fighting, 10 and 20 years after the war, even on Iwo Jima, which is less than five square miles in area.

Like Rubin, who dreaded transfer from Europe to the Pacific, those of us on the scene dreaded the day the mainland would be invaded. We were elated when atom bombs fell and ended the dreadful slaughter.

There has never been any doubt in my mind that the high command underestimated casualties. What general goes into battle expecting to lose half his troops? No one anticipated the deaths of so many at Iwo Jima or Okinawa. Truman could and did read the estimated and actual casualties. Moreover, he had fought in World War I and had personal experience in such matters. The casualties experienced in the last two major battles of the Pacific may well have been ten times the prebattle estimate.

Because Charles Stark Draper was so prominent in developing inertial navigational systems for the military, Reid objects to the National Academy of Engineering's naming a prize after Draper. Reid would like it named for Archimedes. Does Reid object to the Nobel Prizes, including the Peace Prize, because Nobel made his fortune from the invention of high explosives, which caused so much death and destruction in World War I?

Draper became famous with the invention of the Mark 14 antiaircraft gunsight at the outset of World War II. The Mark 14 was developed and deployed within one year of the Japanese attack on Pearl Harbor and Japan's subsequent air victories in the Pacific and East Asia. In 1942, in the battle of Santa Cruz, the Mark 14 enabled the USS South Dakota to destroy at least 26 attacking Japanese planes, turning the odds against Japanese airpower. This device and its successors played a major role in carrying the war to the enemy. It was of great help in defending our forces against the suicidal kamikazes. Airborne equivalents defended the air force against superior forces during the Korean War. The inertial navigation systems for which Draper is best known are the lineal descendents of the Mark 14 gunsight and a consequence of his work on aircraft navigational instruments in the 1920s.

SIDNEY LEES
12/89 Newton, Massachusetts

The exchange between Lawrence G. Rubin and Barton Bernstein omits any discussion of a potent but little-known factor in the problem of whether to drop nuclear bombs on the Japanese: Japan, already short of food and war materials, was unable to use its remaining shipping, an asset vital to a thickly populated island nation. The necessary ports on both the islands and the Asian mainland were full of very potent mines of several types. Only small boats, preferably of wood because some of the mines were magnetic, could carry cargoes with safety.

On 27 March 1945, B-29s of the US Army Air Force filled Shimonoseki Strait, Japan's primary waterway, with 2000 navy mines of various kinds. In each of the next five nights an important Japanese harbor was heavily mined. The pertinent harbors of the Asian coast were also mined.

These operations were classified at the time, but their existence must have been known to those planning the use of the nuclear weapons in August. Our mines had previously been used on a small scale to harass Japanese traffic as our forces fought their way up the east coast of Asia.

Mining the home waters of Japan became relatively easy when we were able to move our main mining base to Okinawa. To destroy the base the Japanese moved Yamata, the mightiest of their battleships, out the "front door"—all other routes being full of our mines. Yamata was easily sunk by our torpedo planes as soon as she reached open water.

Mines are not very popular in our navy. They are sneaky and not a bit heroic. Their design, construction and use were left largely to the naval reserve and its many friends. The one mine we had, the Mark 6, was designated to protect our harbors. We were without experience with aircraft-laid mines with influence firing devices. The navy went to the Department of Terrestrial Magnetism of the Carnegie Institution of Washington

for help. Ellis Johnson, a specialist in magnetism who had been a student of mine at MIT, was assigned to the navy to help.

The first job was to demagnetize the ships of our navy, and then our merchant marine. Ellis suggested they call me in to help. (I was a member of the naval reserves and had already offered to help with the German mines.) Together we guided the expansion of the mine section of the Naval Ordnance Laboratory from two physicists and two engineers to about 800 scientists and engineers, with qualifications from Nobel laureate on down.

We received great help from the British in degaussing. Ellis devised faster methods of measuring the magnetism of ships. Robert H. Park, one of our earliest and ablest recruits, working on a captured German magnetic mine, had more than a thousand mines of similar design in hand by the time we were attacked at Pearl Harbor. By early 1942 Ellis had led in the development of a plan for mining the home waters of Japan—as the efforts of the expanding staff were turned to creating an adequate armory of sea mines for our navy. When it was appropriate, Ellis persuaded General Curtis LeMay of Army Air to offer to take over the mining of the home islands with his B-29 bombers—and Admiral Chester Nimitz to accept the offer. The efforts of the Japanese to pass ships over our mine barrier cost them another million tons of shipping.

It was clear by June that Japan was effectively isolated and unable to carry on any more offensive fighting. However, it was also clear that an attempt at land invasion could be very costly in terms of lives on both sides. With Japan's obvious loss of power, a fraction of our forces in the area could have maintained peace, and Japan would have eventually surrendered.

RALPH D. BENNETT
San Francisco, California
1/90

REID REPLIES: I appreciate the contents of Ralph Jacobson's, Arthur C. Clarke's and especially Sidney Lees's letters. However, I fear that my original letter may have been misunderstood to be critical of Charles Stark Draper. I only hope this letter more clearly and carefully communicates my feelings.

In my original letter, I proposed that Archimedes exemplified an ideal "peaceful" engineer. Although he achieved considerable fame in the last three years of his life at Syracuse designing and constructing war machines used to defend the besieged city, today he is celebrated for discovering the principles of buoyancy and leverage, for inventing the water screw, for his very precise calculation of π and much more. Still, both Archimedes and Draper, because of the geopolitical environments of their times, engaged in military research, something all too often required of great minds. I do not condemn the military work of Draper or Archimedes. What I am concerned about is the apparent "celebration" of this research.

It seems that the moral justification for military research begins with society's need to defend itself against aggression—or as Jacobson puts it, the need "to deter war." A scientist or engineer motivated by the need to deter war is able to do weapons research without a sense of moral conflict. Yet the same scientist or engineer turns those weapons over to potentially less scrupulous authorities who, contrary to his or her vision, may use the weapons to "make war." It seems naive to think that "free" nations have some immunity to this danger. There have been a number of instances since World War II when the United States and other free nations have acted with open aggression to further their own interests. The question is, Should scientists and engineers shoulder some of the responsibility if the weapons they design are used inappropriately? I think they should. Ideally, the scientists and engineers would like to guarantee that such weapons are used wisely and for defense. But how can they guarantee this? And if they can't, then what should they do? As Clarke points out, these are difficult questions with no easy answers. The scientist or engineer must come to terms with the fact that the products of military research can be used criminally as well as heroically. This uncertainty makes me wary of the whole affair and leads me to question its celebration.

Nevertheless, I do agree that defense research is important. We have the right to prepare for aggression as well as to defend ourselves against it. However, how much military research is appropriate? Jacobson enjoys President Bush's company in the argument that because our society's quality of life has apparently improved due to new technologies "spun off" from weapons research, this research is therefore good (and justifies continued funding). This argument ignores the possibility of directing the same minds and resources toward nonmilitary research. If this were done, it is conceivable that many new and more useful technologies would be developed.

Finally, to Lees, I would like to point out just one thing. Alfred Nobel had a vision of peaceful uses for high explosives, and for this reason he developed them. In fact, he rather naively believed that his explosives would lead to the outlawing of war by making it too horrible. So I find it especially significant that the five annual prizes he established are awarded in a spirit of idealism and that one is for the promotion of world peace.

BRIAN REID
University of Western Ontario
London, Ontario, Canada
9/90

BERNSTEIN REPLIES: Sidney Lees is too sure of the age division between "revisionists" (his word) and others about the necessity of using the A-bomb in 1945. If he defines revisionists (as he seems to do) as those *analysts* who believe the bomb was probably unnecessary, then he will find that their ranks include many who labored as adults for their government in World War II. Perhaps foremost among them would be Herbert Feis, a longtime pillar of establishment history writing, and Paul Nitze, a leading cold warrior for decades. Others include Thomas K. Finletter, who later became Truman's Secretary of the Air Force; Carl Marzani, a wartime intelligence officer; historian William A. Williams, an Annapolis graduate and naval officer injured in World War II; and P. M. S. Blackett, the distinguished physicist. In addition, writers Norman Cousins and Hanson Baldwin, the wartime military analyst for *The New York Times*, were early "revisionists." So were many members of the United States Strategic Bombing Survey, whose 1946 "Summary Report" concluded, "Certainly prior to 31 December 1945, and in all probability prior to 1 November 1945, Japan would have surrendered even if the atomic bombs had not been dropped, even if Russia had not entered the war, and even if no invasion had been planned or contemplated."

Lees is correct that the Japanese often fought bitterly and did not surrender, but he omits that they sometimes did not fight to the end and chose instead to surrender. Iwo Jima and Okinawa were very bloody and not really typical struggles. That is part of the reason that those battles, with so many killed on each side, are still painfully recalled as part of the horrors of World War II.

Lees raises important issues about whether US military leaders general-

ly underestimated US fatalities and injuries before a battle, whether these leaders erred by about 1000% in the cases of Iwo Jima and Okinawa, and thus whether Truman, having had experience as an army captain in World War I, had learned to discount prebattle estimates. Unfortunately, Lees seeks to resolve these questions without evidence. To learn more about these issues, he should read the published White House minutes for 18 June 1945, where General George C. Marshall, army chief of staff, and others discussed in front of Truman the planned Kyushu invasion. Lees should also ponder the fact that the 12 300 Americans killed in the spring of 1945 Ryukus campaign (mostly at Okinawa) were under 5% of the total US forces engaged in that campaign. In late May, for example, the US had 168 000 soldiers, 59 000 marines and 22 000 sailors in that campaign. Does Lees really believe that US military leaders, pre-Okinawa, forecast only 1230 US dead, roughly *0.5%*?

In 1945, US air force and navy leaders usually did prefer alternatives—conventional bombing for the air force, and blockade for the navy—to the two planned invasions (Kyushu in November 1945, and Honshu in March 1946). But in the crucial summer of 1945, these men seem never to have argued their case before the President, and thus General Marshall, *a man whom Truman revered and trusted*, triumphed in devising the American strategy for conducting the war: invasion.

In line with navy proposals in spring and summer 1945, Ralph Bennett usefully reminds readers of the great injury that the sea mines did to the Japanese economy and war machine. The mining campaign was part of the navy's strategy for helping to win the Pacific War without an invasion. A few weeks after V-J Day, an air force officer briefly summarized the contribution of the Twentieth Air Force to "the most intensive mining campaign in the history of warfare": Over 1400 B-29s delivered more than 12 000 mines in enemy waters. "The home islands of the enemy were virtually completely severed from her sources of vital food and raw materials on the Asiatic continent."

Interestingly, General Curtis LeMay, commander of the B-29s in the Pacific, had chafed at the orders to drop mines. He periodically protested to Washington. He wanted, especially after the firebombing of Tokyo in March 1945, to concentrate on the heavy bombing of Japan's cities. That was the dominant air force strategy, phrased bluntly by General Henry ("Hap") Arnold, commanding general of the air force, when he privately wrote that American bombers should destroy Japan's cities. That purpose, widely endorsed by American citizens, easily led to the rationale for using atomic bombs on noncombatants. Postwar contentions that the A-bombs saved "a half-million" or more American lives have blocked many from pondering the alternatives.

BARTON J. BERNSTEIN
Stanford University
8/90 *Stanford, California*

Was Uhlenbeck History 'Cannibalized'?

In the December 1989 issue (page 34) Abraham Pais writes that two relatives of George Uhlenbeck, Dutch army officers during the Atjeh wars in northern Sumatra around the turn of the century, "threw themselves on their sabres to avoid capture by cannibals." I am not aware of any credible evidence to suggest that the Atjeh freedom fighters engaged in cannibalism.

SIDNEY VAN DEN BERGH
Herzberg Institute of Astrophysics
Victoria, British Columbia,
12/89 *Canada*

PAIS REPLIES: Originally I had written "brutal tribes" instead of "cannibals." That is also the term used in my book *Inward Bound*. I should have caught the editor's change.

ABRAHAM PAIS
Rockefeller University
4/90 *New York, New York*

APS Input Needed on Nuclear Output

A recent issue of *Greenpeace* magazine states that the Nuclear Regulatory Commission intends to reclassify certain low-level radioactive wastes as being below regulatory concern and therefore disposable in ordinary landfills. Greenpeace urges opposition to this.

It seems to me that here is an issue where physicists not only can but should provide guidance to the public. Perhaps a committee of experts, not in any way connected with the NRC or the nuclear industry, could be formed to look into the matter? The problem of radioactive wastes is so important, especially for the future, that the APS might well have a standing committee advising the government about policy in this field.

IVAN LADANY
3/90 *Harborton, Virginia*

THE PRESIDENT OF APS REPLIES: We thank Ivan Ladany for his suggestion, which will be considered by existing committees of the society.

EUGEN MERZBACHER
University of North Carolina
5/90 *Chapel Hill, North Carolina*

Correction

September, page 20—The decay chain from uranium-238 to U^{234} was misstated: U^{238} emits an alpha particle and then undergoes several beta decays to become U^{234}. ■

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION
(Act of 12 August 1970; Section 3685, Title 39, USC)

1. *Title of publication:* PHYSICS TODAY
1A. *Publication no.:* 0031-9228
2. *Date of Filing:* 1 October 1990
3. *Frequency of issue:* Monthly (12)
3A. *Annual subscription price:* $85.00
4. *Location of known office of publication:* 500 Sunnyside Blvd., Woodbury, NY 11797.
5. *Location of the headquarters or general business office of the publisher:* 335 East 45th St., New York, NY 10017.
6. *Names and address of publisher, editor and managing editor:*
Publisher: American Institute of Physics, 335 East 45th St., New York, NY 10017.
Editor: Gloria B. Lubkin, American Institute of Physics, 335 East 45th St., New York, NY 10017.
Managing editor: Paul Hersch, American Institute of Physics, 335 East 45th St., New York, NY 10017.
7. *Owner (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual, must be given):* American Institute of Physics, 335 East 45th St., New York, NY 10017.
8. *Known bondholders, mortgagees and other security holders owning or holding one percent or more of total amount of bonds, mortgages or other securities:* Guardian Life Insurance Company of America (mortgagee), 201 Park Ave. South, New York, NY 10003.
9. *Extent and nature of circulation:*

	Average*	August**
A. *Total number of copies printed (net press run)*	117 619	121 513
B. *Paid circulation*		
1. *Sales through dealers and carriers, street vendors and counter sales*	none	none
2. *Mail subscriptions*	111 370	115 068
C. *Total paid circulation*	111 370	115 068
D. *Free distribution by mail, carrier or other means, samples, complimentary and other free copies*	2 011	1 903
E. *Total distribution (sum of C and D)*	113 381	116 971
F. *Copies not distributed*		
1. *Office use, left over, unaccounted, spoiled after printing*	4 238	4 542
2. *Returns from news agents*	none	none
G. *Total (Sum of E, F1 and 2—should equal press run shown in A)*	117 619	121 513

* *Average number of copies of each issue during preceding 12 months.*
** *Actual number of copies of single issue published nearest to filing date.*

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Arthur T. Bent, Treasurer