

FISCAL PHYSICISTS

I think it was Ernest Rutherford who once stated, "Science is divided into two categories, physics and stamp-collecting." If this were true, physicists who dabbled in philately on the side could claim sweeping scientific expertise. Alas, it isn't and we can't. But many physicists, in fact, are avid collectors of stamps (Hans Bethe among them, I understand) and of other things.

My particular enthusiasm is banknotes, and the ones depicting physicists in particular. Compared to the world of stamps, the number of banknote designs is rather small, and their primary function rather serious, so there is great prestige attached to having one's portrait on a banknote. Historically, paper currency has tended to depict monarchs, political leaders and military figures—George Washington, Simón Bolívar, Saddam Hussein and the like. Starting around World War II, however, some countries began putting other luminaries, including physicists, on their money. By now the number of banknotes featuring such "fiscal physicists" is sufficient to make an interesting thematic collection (see the accompanying table).

One of the earliest examples of a physicist on a banknote is the philosopher-scientist René Descartes, who first appeared on the French 100-franc note in 1942. Since then, a number of countries, including France, Denmark, the UK and Italy, have issued several banknotes featuring physicists. Only one physicist has been so honored by the US, but Benjamin Franklin's accomplishments in physics were probably not what put his portrait on the \$100 bill. (Incidentally, Franklin has appeared on the \$10 and \$50 bills as well.) The physicist appearing on the largest number of different banknotes is, by a wide margin, Rudjer Bošković (Who? you may ask—as I did; see the caption for figure 1 to learn more). He appears on all 12 denomi-

Physicists are among the select few individuals to be immortalized on banknotes.

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FIGURE 1. IN CROATIA, he's famous: Physicist and Jesuit priest Rudjer Bošković was born in 1711 in what is now Dubrovnik. Although Bošković lived most of his 76 years in Western Europe, his Croatian roots were enough to get him on the country's 1993 series of banknotes. The diagrams to the right of the portrait are from his magnum opus, *Philosophiae naturalis theoria*, which hints at a field theory approach to physics.

nations in Croatia's 1993 series of notes, from 1 to 100 000 dinars. Albert Einstein is one of the few physicists to appear on a banknote of a country of which he was not a citizen (Israel), and Marie Curie is, as far as I know, the only physicist to make it onto the banknotes of two different countries (Poland and France).

Few are chosen

What selection rules govern who appears on a banknote and who does not? The decision process is obviously a bureaucratic one, and different countries undoubtedly use different criteria. The observational evidence supports only a few general inferences. Individuals depicted must have at least national recognition. Among 20th-century physicists, being dead is necessary but not sufficient, as is having a Nobel Prize (Erwin Schrödinger

and Niels Bohr have made it; Werner Heisenberg and P. A. M. Dirac have not). It is also useful to hail from a country with a relatively small number of world-famous citizens; thus the 1992–93 series of New Zealand banknotes that includes Ernest Rutherford's picture on the \$100 bill also honors the explorer Edmund Hillary (\$5), the suffragist Kate Sheppard (\$10) and the Maori educator and politician Apirana Ngata (\$50). Absent from the list is the New Zealand-born writer Katherine Mansfield—even in a small country, international recognition does not, in itself, guarantee you a slot on a banknote. Being a US citizen is practically the kiss of death: It is government policy not to change the portraits on the country's banknotes, in large part because of the controversy that attends even the slightest alteration in design.

By studying a list of pre-20th-century individuals who have been featured on banknotes, one can infer another general rule, of a probabilistic character. For example, the 1962–70 French series that has Blaise Pascal on the 500-franc note also includes Louis Pasteur (5 francs), Voltaire (10 francs), Jean Racine (50 francs) and Pierre Corneille (100 francs). Other (nonpolitical, nonmilitary) luminaries on French banknotes in other series are Victor Hugo, Hector Berlioz, Eugène Delacroix, Claude Debussy,

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Checklist of fiscal physicists*

Physicist	Country, denominations, year of issue
Niels Bohr	Denmark, 500 kroner, 1997
Rudjer Bošković	Croatia, 1 to 100 000 dinars, 1993
Nicholas Copernicus	Poland, 1000 zlotys, 1965 and 1982
Maria Skłodowska Curie	Poland, 20 000 zlotys, 1989
Marie and Pierre Curie	France, 500 francs, 1994
Democritus	Greece, 20 and 100 drachmai, 1955 and 1967
René Descartes	France, 100 francs, 1942–44
Albert Einstein	Israel, 5 lirot, 1968
Leonhard Euler	Switzerland, 10 francs, 1979–present
Michael Faraday	UK, £20, 1991 and 1993
Benjamin Franklin	US, \$50, 1874; \$10, 1879; \$100, 1929 and 1996–present
Galileo Galilei	Italy, 2000 lire, 1973, 1976 and 1983
Carl Friedrich Gauss	Germany, 10 mark, 1989 and 1991
Christiaan Huygens	The Netherlands, 25 gulden, 1955
Lord Kelvin	Scotland, £20 and £100, 1972
Isaac Newton	UK, £1, 1978–82
Hans Christian Ørsted	Denmark, 100 kroner, 1961–70
Blaise Pascal	France, 500 francs, 1968–92
Ole Rømer	Denmark, 50 kroner, 1950–70
Ernest Rutherford	New Zealand, \$100, 1993–present
Erwin Schrödinger	Austria, 1000 schilling, 1983–97
Allesandro Volta	Italy, 10 000 lire, 1984

*The list omits engineers and mathematicians who made physics-related contributions, such as Guglielmo Marconi, Nikola Tesla and Niels Abel (of Abelian group fame).



FIGURE 2. MICHAEL FARADAY, shown here on the reverse of the British £20 note, is remembered not only for his law of induction but for his popular lectures on scientific topics.



FIGURE 3. FRANCE'S 500-FRANC NOTE features, on the obverse, Marie and Pierre Curie and the *voiture radiologique* driven by Marie during World War I; on the reverse is the distillation apparatus she used to extract radioactive salts from pitchblende.

Montesquieu and Molière. Now, if French physicists were to complain that Joseph Louis Lagrange, Pierre-Simon Laplace, André-Marie Ampère and Augustin Fresnel (to say nothing of chemists such as Antoine Lavoisier) also deserve their own banknotes, the likely response would be that so do Montaigne, François Rabelais, Jean Jacques Rousseau, Camille Saint-Saëns and so forth *ad nauseam*. As a consequence, it appears that, at least on the banknotes of European countries, fiscal physicists will continue to be outnumbered by nonphysicists in a ratio of somewhere between 4:1 and 10:1. Such a statistical rule is clearly of little value in predicting the odds of a given physicist's finding his or her way onto a banknote: Nicholas Copernicus, Galileo Galilei and Isaac Newton have their notes, Johannes Kepler does not; William Thomson (Lord Kelvin) is on, James Joule, Hermann von Helmholtz, Rudolf Clausius and Sadi Carnot are off; and such a list could be considerably extended.

Banknote physics

The serious purpose of banknotes tends to discourage frivolity in design, and indeed, some banknotes could be described as truly artistic. Furthermore, their size permits the inclusion of detail not possible on, say, a postage stamp. And so it is that many of the notes portraying physicists also include related motifs. The 100-kroner Danish note depicting Hans Christian Ørsted, for example, also shows a north-south-directed wire between the ends of a voltaic pile atop a compass whose needle is deflected from (presumably magnetic) north, in recognition of Ørsted's discovery of induced magnetic fields. Similarly, the £20 British banknote showing Michael Faraday (figure 2) includes a vignette that depicts him standing before an audience and is labeled "Royal Institution Christmas Lectures

initiated in 1826/the magneto-electric spark apparatus."

The physics-related details on France's 500-franc note featuring Marie and Pierre Curie (figure 3), the only note I know with *two* physicists, are particularly noteworthy.¹ On both its obverse and reverse is an indication of the alpha, beta and gamma emissions from a radioactive source, plus (on the obverse only) the secondary (delta) radiation induced by the gamma beam; also on the obverse is a silhouette of Marie's *voiture radiologique*, the mobile radiological lab that she used to diagnose wounded soldiers during World War I. On the note's reverse is a representation of the distillation apparatus used to "concentrate" the radioactive salts from pitchblende, along with the inevitable symbolic atom.

This banknote also highlights some of the security features that have been introduced recently to discourage counterfeiting. On the 500-franc note, such features in-

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A fun though not cost-free hobby

The mechanics of banknote collecting is pretty simple. The recognized reference is Albert Pick's three-volume *Standard Catalog of World Paper Money*², universally referred to as "Pick." Volumes 2 and 3 (which cover, respectively, "general issues" and "modern issues") are the ones needed to keep track of fiscal physicists. In addition, the International Bank Note Society, based in Racine, Wisconsin, puts out a quarterly journal (edited by physicist-collector Steve Feller) and a newsletter and sponsors meetings where collectors and aspiring collectors gather.

Most of the banknotes listed in the accompanying table can be readily found, being recent or current issues. Unfortunately for the collector on a budget, physicists tend to appear on rather high denominations (for example, Erwin Schrödinger on Austria's 1000-schilling note, Niels Bohr on Denmark's new 500-kroner note). Perhaps that's a sign of their high prestige—or perhaps not.

clude a metallic strip and a watermark picture of Marie that is different from the printed portrait. There is also a feature I have seen on no other note to date: The " β " on the obverse is partially obscured by the symbolic beam of beta radiation, but when the note is held up to the light, the print from the reverse completes the Greek character. This feature requires that the printing on the two sides be very carefully registered, quite a challenge to the would-be counterfeiter. Finally, in clear shiny ink just above the serial number is printed the symbol " $^{226}_{88}\text{Ra}$," the longest-lived isotope of radium. (Because many of these features are designed to be difficult, if not impossible, to reproduce photographically, they do not show up in the accompanying figures.)

But even sophisticated security measures are not always effective. The 1992–93 New Zealand notes, for example, incorporate a metallic strip and a watermark portrait of Queen Elizabeth. Nevertheless, more than NZ\$1.2 million, in \$20 and \$100 denominations, was counterfeited (and at least NZ\$500 000 circulated) before the forgers were caught. In that case the paper was wrong and various ink pens were used to simulate the metallic strip and watermark. But since most people do not inspect their currency very closely, even fairly crude counterfeits can have a significant street life.

In the US, the new \$20, \$50 and \$100 bills also sport impressive anticounterfeiting features, many of which are easy to see but hard to duplicate. The old designs, by contrast, could be easily faked with near-perfect accuracy. Such counterfeits circulate so extensively overseas, in fact, that in some countries US\$100 bills of the old design are no longer accepted.

A current topic of hot debate in numismatic circles is whether currency provides greater security than electronic cash transfers in terms of theft, fraud and privacy. That debate may be academic at this point. Credit cards, debit cards and other such electronic devices are well on their way to gaining universal acceptance, and they will likely spell the demise of banknotes, just as the ubiquitous use of electronic communications will be the end of stamps. As a consequence, the window of opportunity for fiscal physicists, which opened in the middle of this century, may very well close before the middle of the next one. Collectors, take note!

References

1. R. Feller, *International Bank Note Society Journal* **36**, 8 (1997).
2. A. Pick, *Standard Catalog of World Paper Money*, 3 vols., Krause Publications, Iola, Wisc. (1995, 1996, 1998).