feature article

What's wrong with these stanzas?

N. David Mermin

Enough of idle talk and twaddle. Let's celebrate the standard model.

N. David Mermin is a retired professor of physics, living in Ithaca, New York. Like Professor Mozart, he too has tried his hand at physics poems, but the Onegin stanza is more than he can handle. "It's harder than sudoku," he says.

Longtime readers of Reference Frame may remember my opinionated, cigar-smoking friend Professor Mozart, who last appeared in PHYSICS TODAY in August 1999 (page 11), having dropped in on me after seven years of retirement on a small tobacco plantation in Connecticut. Another eight years having passed, there he was again, at my office door. "W. A.!" I shouted with surprise and delight. "How's the tobacco business?"

"Left it," he growled. "Taken the pledge." And indeed, he gave off no smoky aroma. "Bought a vineyard. Napa Valley. Took up poetry. Thirty-third anniversary of the November revolution of 1974. Third of a century. Time to celebrate with commemorative verses." He sighed. "Brought the project to the attention of the poet laureate. Doesn't know enough physics. So," he added in a business-like tone of voice, "I did it myself." And before I could say another word of welcome, he declaimed:

I have always found it risible
That "atom" should mean indivisible,
When deep inside all atoms lie
Their very tiny nuclei,
Containing almost all the mass,
Surrounded by a foggy gas:
Electrons! We should all be proud
Of what we know about that cloud,
Whose properties were once a mystery
But now belong to science history:
An explanation full and blemish-free
That underlies the whole of chemistry.
And yet the story's even richer.
Within the nucleus we picture
Nucleons—still smaller particles,
About which I could write whole articles.
But let it here suffice to say
The two varieties that they
Possess. (1) Protons with a charge
Of electricity just large
Enough to hold electrons in
Those clouds in which they whirl and spin.
(2) Neutrons: uncharged partners of
The protons, held to them as love
Binds lovers in their warm embrace,
Though bound by mesons in this case.
What could be to God's greater glory?
And yet there's much more to the story!
The nucleons themselves have pieces
Described in many a doctor's thesis.
The Standard Model is the name
Of this subnucleonic game.
It underlies the interplay
Of everything. And so, I say:
Enough of idle talk and twaddle—
Let's celebrate the Standard Model!

At this he took a deep bow. "Very nice, Bill," I said politely, "but don't you think 18 unrelieved couplets get a bit bumpy?"

"The uniformity is relieved by the random variation of 8 feminine (*twaddle-model, glory-story, . . .*) and 10 masculine (*name-game, charge-large, . . .*) rhymes. And if you hadn't interrupted me so rudely, you would have found out that the crude simplicity of this prologue offsets the splendor of the hymn to the standard model that follows in 12 Onegin stanzas! It's the poetic equivalent of the switch from black and white to color, when Dorothy walks out the door into the Land of Oz!"

"Onegin stanzas?" I inquired.

Muttering "*Nekulturniy*—you're not in Kansas any more" under his breath, Mozart sighed, and then explained patronizingly, "Pushkin's great verse novel, *Eugene Onegin*, is composed entirely of 14-line stanzas in iambic tetrameter, with the rhyme scheme *aBaBccDDeFFeGG* with *a, c, e* feminine and *B, D, F, G* masculine. People," he added more brightly, "have been writing physics poems at least since James Clerk Maxwell. But nobody—not John Updike, not even Douglas Hofstadter—has ever attempted to match the intricacy and harmony of fundamental physics to that exquisitely subtle and demanding form."

"How can anybody who rhymes 'richer' with 'picture', not to mention 'blemish-free' with 'chemistry,' hope to imitate Pushkin?" I inquired, unable to disguise my irritation.

"Hush!" he ordered. "Listen!" And *espressivo molto*, he began to recite.

The standard model

(1)

The up and down quarks are the units
That make both nucleons behave
In just the manner that they do. It's
Extremely simple. Note that they've
Both got inside them little pieces.
The nucleons are like valises,
Containing quarks. We now agree
A nucleon is made of three
Internal quarks. Quite elementary:

The protons are two ups, one down,
All bound together like a crown.
In Nature's book another entry:
The neutrons are two downs, one up,
Together, just as in a cup.

(2)

The protons all have just one unit
Of charge, electrical. Although
The neutrons lack charge, yes they do! (It
Permits them easily to flow
Through crystals.) But this neat arrangement
Requires some genuine estrangement
From common notions. Thus, the charge
Of up quarks isn't all that large:
Only two-thirds the normal portion
That one expects a charge to be.
What's more, the down quark, cunningly,
Has just *one*-third. And here's a caution:
Up and down charges, that combine,
Are furnished with a different sign.

(3)

So up-down-down has full charge zero
While up-up-down has full charge one.
It doesn't take a superhero
To realize the job's now done.
Our tripling has been quite delightful:
The proton's charge is just its rightful
Amount. The other way quarks fall,
The neutron gets no charge at all.
Next, you may ask what is the tether
That holds these trios in one place
Instead of wandering through space?
What makes three quarks remain together?
The gluons! Gluons do the job
Of making quarks a single blob.

(4)

The way in which the gluons tie in
A group of quarks to just one place
Deserves a mention very high in
Examples of a strong embrace.
For if you try to tear asunder
Three quarks you make a dreadful blunder:
You'll find the harder that you try,
The stronger bond the gluons tie.
For gluons bear the strict assignment
Not to let single quarks appear.
I ought to make that very clear.
This property is called confinement.
However much you try to free
A single quark, it cannot be.

(5)

Each nucleon's a three-quark triple
One up, two downs; two ups, one down.
But there's another little stipul-
Ation that has acquired renown.
All quarks have color. This is knowledge.
Although you'll learn in any college
It's not the kind that you can see
But just a form of poetry.
The colors don't come in profusion.
One quark is red, one green, one blue.
That's all there is. I'm telling you
To ward off possible confusion.
And here's a final piece of news:
The anti-quarks have anti-hues.

(6)

The anti-red-quark, for example,
Has to be colored anti-red.
Likewise, I'm sure it wouldn't trample
The preconceptions in your head
To learn the hue of anti-blue-quarks
Is anti-blue. And like all true quarks
The anti-green-quark has to mean
A quark that's colored anti-green.
Now here's a rule that's quite delicious:
The red and green and blue make white.
The color's disappeared, all right.
And though it may not sound propitious
When color, anti-color play
All of the color goes away.

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(7)

All particles are colored purely
Neutral if they're directly seen.
In nucleons the three quarks surely
Must then be red, and blue, and green.
Another way that's somewhat duller
To make up something lacking color
Directly puts together two
Paired quarks of hue and anti-hue.
In just this way one makes a meson,
Like pion, eta, kaon, rho
And other ones you might not know
Unless you have a special reason.
Only the parts have color. Yes,
The things we see are colorless.

(8)

Now up and down are not the only
Varieties that quarks possess.
In case you worried they'd be lonely,
You needn't fear. For I confess
There are two other generations
That furnish quarkish explanations
Of why there is so big a zoo.
Each generation comes with two
Fine quarkish partners. One pair's charmed
And strange. The other's bottom, top.
This makes you wonder, will it stop?
No problem. Do not be alarmed!
There's nothing else we need to fix.
The quarkish flavors stop at six.

(9)

Now all of us have often spoken
About electrons, tiny things.
They too have partners (I'm not jokin'!)
That swiftly fly as though on wings.
Neutrinos have the smallest masses
Of all the fundamental classes
Of particles. As I recall
They've hardly any mass at all.
Through endless ranks of rocks and boulder
At speeds approaching that of light
They pass unhindered in their flight.
There's almost nothing that can shoulder
Those swift neutrinos off their path.
We live in a neutrino bath!

(10)

Here too things come in generations.
A heavy 'lectron called the mu
Is one of God's more strange creations.
And has its own neutrino, too.
A third neutrino fills the picture.
Following a familiar stricture,
Which surely isn't broken now,
Its partner's the still heavier tau.
Electron, mu, and tau along with
All their neutrinos, commonly
Are known as leptons. These make three
New generations that belong with
The three quark pairs. The same format!
Well might one ask, "Who ordered that?"

(11)

A flavor-changing transmutation
Is called a weak decay. And there's
Accompanying it the swift creation
Of lepton–antilepton pairs.
The down-quark–up-quark weak transition—
"Beta decay" (from old tradition)—
Creates electrons, moving fast,
And antineutrinos in the blast.
This is the way that neutrons trouble you,
Turning to protons with the aid
Of two assistants, that are made
Of new gauge fields. Called Z and W
They're massive cousins to a sprite:
The massless photon, speck of light.

(12)

Behold the Higgs! The most elusive
Of particles, I do insist.
Not yet observed, we lack conclusive
Data to show that they exist.
Without the Higgs there'd be no masses
Creating some grotesque impasses.
This means within the Standard tale
The Higgs's the crucial Holy Grail.
Please do not doubt the Higgs' reality.
We're hoping very soon to learn
From evidence produced at CERN
That it exists, with clear finality.
So don't forget: *The Higgs's the thing*
That makes the Standard Model king.

Mozart uttered the last line and a half in italics, then stood quivering with his eyes shut. For me, the lines resonated with something. *The Cray's the thing that puts our computations on the wing*? No. Or perhaps the more esoteric, *The splay's the thing that gives nematic liquid crystals zing*? Not really. Oh, I know—

But just as it was coming to me, Bill Mozart emerged from his reverie, gave me a little wave of his hand, and disappeared down the corridor. He left behind him 18 couplets and 12 Onegin stanzas, handwritten in his characteristically florid strokes. I have reproduced them here, without attempting to correct their (surprisingly) few imperfections, for the edification of the physics community on this, the one-third centennial of the November revolution. ■

PHYSICS TODAY has learned that the verses David Mermin attributes to "Professor Mozart" were, in fact, written by himself, as a narrative to accompany "Carnival of the Subatomic Particles," composed by Mark G. Simon for flute, clarinet, violin, cello, and piano, in celebration of the 30th anniversary of the first beam injection at the Wilson Synchrotron Laboratory. "Carnival" had its world premier performance in Ithaca, New York, 1 April 2007, by the group Music's Recreation. Excerpts from that performance are available at www.physicstoday.org.