Hiawatha’s Valence Bonding

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There is increasing circumstantial evidence that the cuprate superconductors, and correlated-electron materials generally, defy simple materials categorization because of their proximity to one or more continuous zero-temperature phase transitions. This implies that the fifteen-year confusion about the cuprates is not fundamental at all but simply overinterpreted quantum criticality—an effect that seems mysterious by virtue of its hypersensitivity to perturbations, i.e. to sample imperfections in experiment and small modifications of approximation schemes in theoretical modeling, but is really just an unremarkable phase transition of some kind masquerading as something important, a sheep in wolf’s clothing. This conclusion is extremely difficult for most physicists even to think about because it requires admitting that an identifiable physical phenomenon might cause the scientific method to fail in some cases. For this reason I have decided to explain the problem in a way that is nonthreatening, easy to read, and fun—as a satire modeled after a similar piece of Lewis Carroll’s I once read. My story is humorous fiction. Any similarity of the characters to living persons is accidental. My apologies to Henry W. Longfellow. [Published as Annals of Improbable Research 10, No. 6 (May/June 2004), p. 8.]

I. INTRODUCTION

Since all men have imperfections
Hanging bones inside their closets
That they trust no one will notice
Absent tips on where to find them,
It will shock no one to learn that
Even mighty Hiawatha
Famous Chief of myth and legend
Did some things he was not proud of
While a brother in a frat house
With a surly reputation
At an unknown little college
That his father helped to finance
By the shores of Gitche-Gumee.

Far from loving fields and flowers
And the odor of the forest
As one reads in all the textbooks
Hiawatha hated woodlands
And the animals one finds there,
Whom he felt were always pooping,
And the plants the critters fed on
Down in dank and swampy bottoms,
Nearly perfect grounds for breeding
Mighty hordes of great mosquitoes
Who were always lean and hungry
And equipped with maps and radar
Could detect where you were hiding
To inflict their bites and torments,
With their sneaky friends the black flies,
And their angry friends the green flies,
And the rocks ensnared by tree roots
That existed just to trip you
And would look improved as concrete
In foundation for a condo.

Thus the kindly, thoughtful image
Of a noble man of Nature
Was a total fabrication
Of a team of gifted spin docs
Hired later for this purpose.
He was really just a tech nerd
Who cared only for equations
And explaining all behavior
From the basic laws of physics
Armed with only mathematics.

Thus, instead of lakes and forests,
Hiawatha worshipped Newton,
Whose account of Kepler’s orbits
Built on rules that Galileo
Had inferred from observation
Plus the innocent assumption
Of a law of gravitation
Was a cosmic inspiration;
And the brilliant Sadie Carnot,
Whose insightful laws of heat flow
Were deduced from working engines
Absent microscopic theories;
And the tragic Ludwig Boltzmann
Who ascribed these laws to counting
But fell victim to depression
When he found no one believed him
And so killed himself by jumping
From an Adriatic tower.
Hiawatha saw that Maxwell’s
Guessing missing laws of motion
Needed for predicting light waves,
Was the most transcendent genius,
As was Albert Einstein’s insight
That the speed of light being constant
Must mean time was not consistent
And that mass could be converted
Into heat and vice versa.
Just as clear was that the Planck law
Must imply DeBroglie’s wavelength
Was in force in any matter
So that sharp atomic spectra
And distinct atomic sizes
And the laws of bond formation
Came from quantum interference.

II. HIAWATHA’S MISTAKE

Thus it was that Hiawatha
Came to be infatuated
With the laws of quantum matter,
Which means liquid noble gases,
Neutrons in a burnt-out star core,
Or just rocks so cryogenic
They cannot get any colder,
Even with improved equipment,
Like the state of too much sliding
On the ice of Gitche-Gumee
After dark in dead of winter
In an inexpensive loincloth.
Pain and danger notwithstanding
Quantum matter’s simple structure
Makes the eager physics tyro
Quite unable to resist it.
Hiawatha learned how atoms
Self-assemble into crystals,
How electrons move right through them,
Waving past the rigid ions
Thereby making them metallic
In the absence of a bandgap
Which arises from diffraction
And prevents the charge from moving

They were little more than con men.
So it looked somewhat like science
Even though it really wasn’t.

How they did this was ingenious
For it’s not a simple matter
To produce concrete equations
That are absolutely hokum
And escape without detection
When they represent relations
Of some quantities one measures
Written down as abstract symbols
That could easily be tested.
What they did was deviously prey on
Prejudicial ways of thinking
That their colleagues thought were reasoned
But were simply misconceptions,
Generated during training
They had all received as students,
That the properties one wanted
Were completely universal
So details did not matter.
But the data did not say this
And, moreover, had they done so
There would have been no good reason
To think any more about it.
So, while everyone was watching,
They swapped in some new equations
That they said would solve the problem
On account of being much simpler
But in fact described a system
Very different from the first one
And, moreover, was unstable,
Balanced at competing phases,
So that nobody could solve it
Thus betraying the deception.

Adding to the dazzling brilliance
Of this coldly thought-out swindle
They declared it *fundamental*
So that all the strange creations
Made by people trying to solve it
And quite clearly not succeeding
Proved it was a fount of deepness
One should struggle to unravel
Even if it took a lifetime.
As a nifty added bonus
Any hint you dropped in public
That it might have no solution
Simply meant you weren’t a genius,
Told the world that you were stupid,
That you were a hopeless failure
Who should not command a pencil.
No one wanted to admit this
So they’d cover up their failure
And pretend that they had solved it
Even though they clearly hadn’t.
This succeeded, for the most part,
But in one respect it didn’t,
For their desperate need to publish

And thereby maintain their funding
Caused a massive flood of papers,
Each quite different from the others,
To descend upon the journals
And to overwhelm and clog them.
This would have been very funny
Had it not been so pathetic.

Hiawatha bought the story
Took the bait, hook, line, and sinker
And, like many other students
Who’d been victimized before him,
Got convinced that his strong math skills,
Far exceeding those of others,
Would reveal nature’s mysteries
When he solved the Hubbard model
And its child the t-J model
And the lattice Kondo model
And the quantum spin glass model,
All of which possessed the feature
That no human being could solve them.

III. HIWA THA MEETS THE CUPRATES

Nature has a sense of humor,
As one learns by working with it,
But it is an opportunist,
So that life’s most bitter lessons
Often wind up learned the hard way
When it moves to take advantage
Of a single bad decision
And compound it with some mischief
Custom made for the occasion.

Just when he’d resolved to strike out
On his suicidal mission
There occurred a bold announcement
In a well-known German journal
That a tiny lab near Zürich
Had discovered a material
With the structure of perovskite
Made of oxygen and copper
And some other stuff like strontium
That when cooled to thirty kelvin
Lost all traces of resistance.
This event was simply shocking
For existing quantum theory
Said it had to get much colder
For this special thing to happen,
As did all the careful surveys
Of the properties of metals,
Which were very comprehensive
And agreed well with the theory.
Since the chemists were ambitious
To somehow transcend this limit,
Which they thought too academic,
And someday kill all resistance
Using no refrigeration,
There ensued a feeding frenzy
Worthy of a horror movie,
Like what happens when a trawler
Dumps its hold of tuna entrails
Off a reef in north Australia.

One example of this madness
Was the Physics Woodstock conference
That took place in mid-Manhattan
Shortly after the announcement
Where attendees got together,
Comandeered a giant ballroom,
And gave talks not on the program
In a special all-night session
Dedicated to the cuprates
Which was packed to overflowing.
There was talk of maglev transport,
New kinds of computer circuit,
Mighty, compact little motors
And efficient power cables,
All of which would soon be coming
Thanks to this momentous breakthrough.
But it turns out we don’t have them
For they weren’t a big improvement
Over things we had already
And were hopelessly expensive.

Then there were the frantic searches
To find compounds that were better,
Which one knew could be accomplished
If one spent enough time looking,
Since this stuff had lots of phases
Subtly different from each other,
And there had to be a best one.
There was very rapid progress
Culminating in a patent
For a more complex material
In the same broad class of structure
Which performed at ninety kelvin,
So much higher than the theory
Would allow to ever happen
Even with extreme assumptions
That one knew it was in trouble.

Almost overnight one found that
Every spectrum known to science
Had been taken on a cuprate.
Their alleged profound importance
Was, of course, a major factor,
But what mattered most was tactics.
Without need to tell one’s funders,
Since it could be done so quickly,
One could telephone a chemist,
Cut a deal to get some samples,
Put them in one’s apparatus—
Presto! Out would come a paper
That would instantly get published
Even if it was a stinker.
This produced a pile of data,
Growing without bound, like cancer,
That completely overwhelmed you
By being mostly unimportant,
Like the growing list of options
Coming from your cable service.

Often spectra weren’t consistent,
But, instead of getting angry
As one would have in the old days,
One would handle it maturely
And just chalk it up to errors
That occur when one is hasty.
Or has had bad luck with samples. But this tolerance, it turns out, Was a bargain with the devil For it later was discovered That enormous variation Was endemic to the cuprates, And that things not reproducing Due to complex phase inclusions, Foreign atoms in the sample, Careless oxygen annealing, Surface preparation methods, And a thousand other factors Was essential to their nature.

Sadly, by the time this surfaced Shameful habits of denying That the differences existed Had become enshrined in writing, And so wedded to the culture, That they could not be corrected. It was now accepted practice In a public presentation Of experimental findings Not to mention other data Even if your own group took them. Grounds for this were rarely stated, Other than the innuendo That one’s sorry competition Were a hopeless bunch of bozos Who did not know how to measure And therefore could not be trusted. It was likewise viewed as kosher To make up a little theory Or adopt somebody else’s That gave all your findings meaning— Although not those of your colleagues, Which were, sadly, so imperfect They were simply inconsistent. But one never heard recanting, Since it would have meant admission That one’s judgement had been faulty.

Thus the cuprates’ weird caprices Long escaping understanding Transformed into pseudotheories That, like gods on Mount Olympus, Were political creations That could not be killed with reason And, empowered as immortals, Took control of their creators, Warred among themselves for power, Schemed to have a lot of children, And, in general, made a circus Of the scientific method.

Hiawatha, being a student, And, quite frankly, rather callow Did not have the slightest inkling That such nonsense ever happened.

He believed the claims of science To be rather more objective Than competing kinds of knowledge On account of its precision And the fact that you could test it. Rather than the yawning snake pit Seething with disinformation That was really there before him, Certain death for young beginners, He saw just a chance for glory Something of immense importance, Judging from the acrimony Coursing through the talks and papers, And a vast supply of data On which one could build a theory And thereby become a hero, Much the way the dumber brother Of the famous brave Odysseus That no one has ever heard of, Sure he could outfox the sirens, Ordered that the men unbind him And, of course, succumbing quickly Dove right in and bashed his brains out.

IV. HIAWATHA ESCAPES REALITY

Hiawatha’s misconceptions Of the nature of the problem He was setting out to conquer Were not shared by everybody. Just as buzzards, with keen noses, Circling high above their breakfast Wait until it cannot hurt them, To swoop down and get to business, And ichneuman wasps impregnate Larval caterpillar victims With some eggs that grow to eat them, Thus not let them reach adulthood When they might be hard to handle,
Hiawatha’s crafty mentors
Sensed that science had stopped working
In the sub-field of the cuprates,
As it had before in others
Where their scams had been successful.
Smelling death was close upon it,
They resolved the time was ready.

What ensued was simply awesome,
Destined to go down in legend.
They proposed a cuprate theory
So magnificent in concept,
So much bolder than the others
That it blasted them to pieces
Like some big atomic warhead,
So outshined them in its glory
Like a nova in the heavens
That it blinded any person
Who would dare to gaze upon it.
Cuprates did these things, it stated,
Just because a quirk of nature
Made them like the Hubbard model,
Which, as had been long established,
Did some things quite fundamental,
Not yet known to modern science,
Which explained the crazy data,
So to understand the cuprates
One would have to solve this model.
How colossal! How stupendous!
It was absolutely foolproof!
No one could disprove this theory
With existing mathematics
Or experimental data
For exactly the same reasons
Nor could they admit they couldn’t,
So they’d spend their whole lives trying,
Blame themselves for being so stupid,
And pay homage in each paper
With the requisite citation!

They left clues in great abundance
That they’d made a vast deception
Far surpassing P. T. Barnum’s
Most creative whims and musings
Trusting that no one would catch them
On account of being so guileless,
Which they knew was part of science,
Rather like the clever killer,
Sure he can outsmart Columbo,
Leaving marks upon the crime scene
Then in later verbal sparring
Hints at them in brazen taunting,
One was that its short description,
Resonating bonds of valence,
Was the name that Linus Pauling
Used for common bonds of benzene,
Something so profoundly different
From the physics of the cuprates
That its use on this occasion
Seemed to show a lousy word sense.
But, in fact, it was inspired,
For the permanent confusion
Left by its uncertain meaning
Like the data it reflected,
Was defense against attackers,
Made it very hard to target,
Left its enemies bewildered.
And the thoughtful usurpation
Of a well-established brand name
Had the lovely added feature
Of dispatching pesky Pauling,
Who had always been a nuisance,
Down to Davy Jones’s locker
In the minds of younger people.
There was also the assertion
Running rampant through the theory
That the essence of the cuprates
Was coulombic insulation,
Which, on close inspection, turned out
No one could define precisely,
With a few concrete equations,
But was nonetheless a concept
People thought they comprehended,
Like the fancy secret contents
Of competing brands of toothpaste
That, of course, are total fictions
Made up during lunch by ad guys.
But the best clue by some margin
Was the deus ex machina
Known as Gutzwiller Projection,
Which began life as a method
For controlling the equations
But was morphed on this occasion
To a monstrous distortion
Of the basic mathematics
On the grounds it was insightful.
But, in fact, it came from nowhere,
And was just a simple dictat
That an off-the-shelf conductor
Could not be a quantum magnet
While one forced it to become one
Thus creating awful conflict
When, in fact, there simply was none.

Hiawatha, being clever,
Quickly saw that he could do this,
Saw that such manipulations
Were, in fact, extremely easy,
That a high school kid could do them,
Once he got the key idea
That one should evade the problem
Of deducing the behavior
From the actual equations
By declaring that some answer
Was correct because one said so
And proceeding to defend it
With a lot of complex symbols
Simply cooked up to confuse things.
Thus emboldened to abandon
His perverse outdated fear of
Uncontrolled approximations
Hiawatha bit the bullet
And jumped into cuprate theory
With the fury of a madman,
Doing reckless calculations
Based on nothing but some gas fumes
That produced some fine predictions,
As one was inclined to call them,
Matching some existing data
But, of course, not matching others,
Since they were not all consistent.
He would then just pick and choose them
As one would an orange or lemon
In the local supermarket
And declare the rest defective.
Then he wrote up his conclusions
In a little physics paper
Loaded up with fearsome symbols
Proving that he had credentials
To make all these speculations,
Sent it in for publication
And then found an awful problem
He had not anticipated.
For the paper to be published
It must get past refereeing
Which, in theory, was for stopping
False results from being reported
But, in practice, was to censor
Anyone whose work you hated,
Somewhat of a sticky wicket
For someone who’s main objective
Was to publish speculation.
Hiawatha soon discovered
Though the process of rejection
That his papers could not make it
If they championed new ideas
Or in any way conflicted.
With the viewpoints of the experts
Which, of course, were simply made up.

Thus the mighty Hiawatha
Found his plans to be a scholar
Had an unexpected down side
That would later prove quite fatal
In that he was forced to pander
In his writing for the public
To a set of flakey concepts
That he’d found extremely useful
But had not had time to question,
In exchange for recognition
Needed for career advancement.
For a while it did not matter
But the problem slowly festered
And one day poor Hiawatha,
Waking to a huge disaster,
Found himself up to his eyeballs
In a soup of black corruption.

V. HIAWATHA AND THE EXPERIMENTS

Hiawatha’s revelation
Took a while to find its footing
For, as happens in such cases,
Many awful misconceptions
Were embedded in his thinking
Where they had been put on purpose
And could only be uncovered,
If at all, through painful hours
Scrutinizing tiny details,
Contemplating reams of data,
Finding out who’s stuff was careful,
Tracking down suspicious rumors,
Reading through a mass of papers,
Slowly tossing out the bad ones,
Racking up the airline mileage
Going to humongous meetings,
Thereby building up a fact base
Cleansed of all manipulations.
Over time, as things got clearer, 
Hiawatha grew unhappy 
Trying to reconcile his viewpoint 
With the facts that he had winnowed, 
Always finding that he couldn’t.

Hiawatha studied transport 
Both electrical and thermal 
That, one argued, showed the absence 
Of the Landau fermi surface 
Symptomatic of a metal 
Thereby proving one was dealing 
With a strange new state of matter. 
But he found in every instance 
That a sample made its coldest, 
So one knew what one was doing, 
Either showed disorder problems 
Generated by the chemists 
Or agreed with classic theory. 
Thus, like all those dot-com profits 
That they claimed would make you wealthy, 
But, in fact, were nonexistent, 
Arguments for novel physics 
Built upon the facts of transport 
Did not hold up on inspection.

Hiawatha studied optics 
By and large his favorite spectrum 
For he knew that light reflection 
Measured dielectric functions 
In a way that used no theory, 
And it showed how loose electrons 
Moved about and caused the bonding. 
But, alas, the data varied 
From one sample to another 
Even after years of efforts 
To ensure that they were stable! 
This left lack of clear consensus 
Even over things that mattered, 
Understanding why this happened 
Was not really rocket science, 
For the Kramers-Krönig process 
Amplified the defect signals 
That were there in great abundance, 
Even though they all denied it, 
And depended on the process 
By which one prepared the sample, 
Something different for each grower 
And a closely-guarded secret. 
Also, things would change with doping, 
Something very hard to measure 
And which often wasn’t constant 
As one moved across the sample 
Due to troubles in the furnace 
Which they claimed they’d licked but hadn’t. 
Thus the stories of new physics 
Built upon results of optics, 
Like the troubled U. S. census 
Or the the streets of downtown Boston

After weeks of too much snowing, 
Were polluted by disorder, 
And, moreover, were deceptive 
In that aspects of the spectra 
That were reasonably stable 
Like the strange non-Drude lineshapes 
Happened at such tiny wavelengths 
One could plausibly ascribe them 
To a nearby phase transition 
Rather than the state in question. 
Thus the stories were fantastic, 
And, like those that Richard Nixon 
Told while he was in the White House, 
Or that pop star Michael Jackson 
Claimed occurred in Los Olivos 
For the pleasure of the children, 
In the end would not hold water.

Hiawatha studied neutrons 
Which he found he liked immensely 
Since they flowed from a reactor 
With big purple signs upon it 
Warning you of radiation 
That would kill you if allowed to, 
Since the neutrons went right through you 
But would sometimes choose to stop there 
And decay like little time bombs, 
Thus inducing stomach cancer. 
But they went through cuprates also, 
And that made them very useful, 
Since a few of them would scatter, 
And detecting those that did so 
Gave you lots of information 
From down deep inside the sample, 
Such as how the atoms ordered, 
How they moved when something hit them 
And if they were little magnets. 
But the bad news was the signal 
Was quite small and hard to measure, 
So one needed a detector 
Bigger than a Dempsey Dumpster 
And a truly mammoth sample,
Leading to big compromises
In the sample growing process
They preferred deemphasizing
But one knew was wreaking havoc
On the meaning of the data.
They would also never tell you
What the measurement itself was,
Since the neutron kinematics
Made it sensitive to factors
Like the speed spread of the neutrons
And the tip of the detector
And the path on which one moved things
To survey deflection angles
That were messy and annoying,
So they’d first massage the data
Using big computer programs
To remove these nasty factors
And report the program output,
Representing you should trust it
Just because they were the experts.
But, of course, there were those upgrades
And the quiet little tweaking
That one always did at run time
That one never heard reported.
Once he caught these key omissions
Hiawatha got suspicious,
And quite quickly found the practice
Of reporting neutron spectra
In some secret custom units
Given names like “counts” to fool you,
Like those helpful content labels
Found on packs of sandwich slices
Listing salt and beef by-products,
Thus preventing one from telling
There was very poor agreement.
All this made a clearer picture
But it also meant the data
Like the air-brushed prints in *Playboy*
Were, in fact, manipulated,
And that many strange behaviors
Like the famous funny phonon
Dogma said was nonexistent
Got removed as standard practice
On the grounds they should not be there.
Thus his plan to use those spectra
To pin down the magnetism
Present sometimes in the cuprates
On account of all the errors
Ended up a dismal failure.

Hiawatha studied currents
Made when cold electrons tunnel
Right across an insulator
Where they should have been forbidden,
Something very close to magic
Rather like the twinkly transport
People undergo on Star Trek,
And it’s also quite revealing

Ever helpful content labels.

Of important quantum pairing
That goes on inside the cuprate.
In the old days one would simply
Oxidize a thin-film sample.
Coat the oxide with another,
Solder on two tiny contacts,
Dunk the whole thing into vapors
Made so cold that they were liquid,
Then just measure plain resistance
Of the two protruding wires,
Which would vary with the voltage
Thus producing useful data.
Hiawatha read these papers
With a mounting sense of horror,
For the wild disagreement
Even in the basic features
From one sample to another
Was so large it left one breathless.
And, of course, the accusations
That the other guys were morons
Who just could not make good junctions
Rose to unmatched heights of grandeur
Even though the real villain,
Obvious from spectral sharpness,
Was the sample variation.
Hiawatha’s indignation
Escalated when he found that
Over time this fact got buried
Since each group soon found a method
Of preparing stable samples
Different from that used by others
And producing different spectra
That they marketed as products,
Thus evading any need to
Answer penetrating questions.
An important fact, however,
That emerged from all these studies,
Was that steady lossless currents
Could indeed be made to flow from Films of lead into the cuprates
If one made a pitted surface,
Proving that the state of matter
Operating in the cuprates
Was not new and was not different.

Hiawatha studied spectra
Made when light shined on a sample
Causes it to lose electrons
Which fly out in all directions
And one can detect by counting,
Thus obtaining information
Of their status in the sample
Just before the light removed them.
Hiawatha saw at once that
Peaks for plain undressed electrons
That were not supposed to be there
In this great new state of matter
Always were and had a sharpness
At the resolution limit
Of the latest new detector
For the special ones at threshold,
Where one knew what one was doing.
In addition they were beaming
In a lovely fourfold pattern
With the symmetry of d-wave,
Something that had been suggested
They might do if they were simple,
Just like those in other metals.
Thus the arguments for strangeness
Based on counting these electrons
Lost their force as things got better,
And in time were proved a failure.

Hiawatha studied muons,
Which he thought were even neater
Than the more prosaic neutrons,
Since they came from atom smashers
That could also quickly kill you
If you chose to be so careless,
But they’d stop inside much better
And once there, decay to gammas
That were easily detected
Since they’d even go through concrete,
And, moreover, they’d be beaming
In the muon’s spin direction
Just before it went to heaven.
Thus, implanted in a cuprate
They’d arrest at some location
Known to no one but their Maker
And precess like little searchlights,
If there was some magnetism,
Thus allowing you to see it
Way deep down inside the sample.
Thus with knowledge of their trapping
And a batch of big detectors
One could then back out the distance
Of magnetic penetration.

Hiawatha found this distance
Shortened with increasing doping
Just as theory said should happen,
If one forced the hubbard model
Not to be a quantum magnet
By just saying that it wasn’t,
Which might well have been important
Had it not been for the problem
That this depth would not continue
To decline with increased doping
But instead would turn and lengthen.
This effect was quite perplexing,
Since no theory of the cuprates
Even twisted hubbard models,
Could account for such behavior,
For it violated sum rules,
Hence one just did not discuss it.
But the meaning was transparent
If one faced the facts with courage,
For the samples were degrading
In extremes of overdoping
In some ways that weren’t predicted
And, moreover, weren’t detected
By techniques except for this one.
This, in turn, implied these problems
Might occur at other dopings
And likewise escape detection
Or, what’s worse, be used to argue
That new physics was occurring
When, in fact, it was just garbage.
Thus the trail blazed by muons
Led out in the woods to nowhere.

Dental pamphlets make you tired.

Hiawatha studied spin flips
That the nuclei of atoms
Undergo in great big magnets
Near a radio transmitter
Causing them to be antennas,
Which absorb with complex lineshapes
One can read if one’s a genius
But not, sadly, if one isn’t,
Since they, by and large, consist of
Just a simple blobby bell curve
With a width and displaced center,
To which one must give some meaning—
Not a simple undertaking.
Thus the all-important Knight shift
And spin-lattice relaxation,
Noms de plume for width and center,
Vastly different for the copper
And the oxygen of cuprates,
Were the source of endless theories,
Often very thought-provoking,
Stunning in sophistication,
But, like all those glossy pamphlets
Found in waiting rooms of dentists
Urging you to practice flossing,
Soon began to make you tired,
Since the data mainly showed you
That the stuff was not a metal
In the sense of gold or iron
Which, in fact, one knew already
And was not a revelation.

Hiawatha studied structure
Of the surfaces of cuprates
Freshly cleaved inside a vacuum
So that air would not get on them
And then probed with tiny needles
One could move with great precision,
By adjusting some piezos
On which everything was standing.
What he found was quite disturbing,
For while atoms at the surface
All had unperturbed positions,
Showing that the cleave succeeded,
There were also complex patterns
On the scale of twenty atoms
That appeared to be diffraction.
This behavior might have come from
Atoms underneath the surface
That were missing or defective
Or some novel magnetism
Of a kind unknown to science,
But the thing that so upset him
Was that quantum interference
Of the kind that he was seeing
Could not happen if the lifetimes
Were as short as he had thought them,
And which had been used to argue
For a brand new state of matter.
Thus he soberly concluded
That this matter wasn’t different
And the whole confounded story
Was a misinterpretation
Of a plain materials problem.

Thus the Mighty Hiawatha
Through the patient application
Of the practices of science
Tested over generations
Slowly sloughed off misconceptions
And, in face of mounting failure,
Sadly came to the conclusion
He’d been taken to the cleaners.

VI. HIAWATHA BEFRIENDS THE ROBOTS

Given all the clever swindles
Lurking there to take our money,
That, of course, are part of living,
Like a virus for pneumonia
Or a hungry venus fly trap,
We must all be very thankful
That the celebrated Law of Murphy
 Strikes at random without warning
Causing even brilliant concepts,
That appear completely foolproof
Like distributing tobacco
Or the business plan of Enron,
To sometimes become derailed
Due to something unexpected
One was sure could never happen,
Like a lawsuit from consumers,
That requires intervention
Of the most creative nature
To prevent strategic meltdown.

As it turns out, the idea
That the conflict in the models
One was using for the cuprates
Due to nearby phase transitions
Would both hamper their solution
And engender rampant fibbing,
Thus enshrining mass confusion
One would then call proof of meaning
With no need to fear exposure
Had the unexpected weakness
That someone might solve the model
Using tons and tons of money
And some capable computers
To a crude degree sufficient
To unmask the real problem
Thus revealing the deception.

Sure enough, that’s just what happened.
When the cuprates were discovered
And the whole endeavor started
One had not the slightest worry
That these guys would ever solve it,
Since the accuracy needed
Was not clear in the beginning,
So they uniformly low-balled
With the too-familiar outcome
That results were inconsistent.
So they quarrelled over method
And who had convergence problems
And whose code was most clairvoyant
Even though a child could see that
They were different apparati,
So the test that they were working
Was agreement with each other.
But, unlike the other issues
That had come and gone before it,
Cuprates lingered on as timely
Long enough to cause a shake-out,
For the money kept increasing
Even as machines got cheaper
And their power kept on growing—
Due, of course, to needs of gaming,
Rather than the ones of Lanczos
Or the quantum monte carlo
That one used for basic physics.
So the robots kept on plugging
As their owners upped the ante
Very slowly, as did Wagner
When composing Ring and Tristan
And their stuff began converging!
There, of course, was no agreement
Over matters of the phases
Such as whether it conducted
When one cooled it down to zero,
Since a crystal of electrons
Was one state in competition.
But at length scales one could access
There was clearly dissipation
Of a most peculiar nature
In the dielectric function
And the quantum magnetism,
Just exactly as predicted
By an ancient bunch of papers
Over quantum phase transitions,
Which these guys had never studied

Soon their stuff began converging.

Since it was too esoteric
And had not been seen in nature
And was hated by their funders.
But the thing that really clinched it
Was the endless disagreement,
That got worse as things proceeded
And was very clearly chronic,
Over type and shape of edges
That would best produce convergence,
Since one found that subtle changes
In the way one built the model
Would turn on and off the striping
And therefore the insulation,
So that whether it was present
In the limit of large sample
Simply could not be determined
With the codes that they had written.

This, of course, was a disaster
For the plan to keep things murky
And required drastic action
To somehow repair the damage
All this progress had created,
And prevent these guys from seeing
What was right beneath their noses.

And one was not disappointed.
Once again a flash of brilliance
Like a great big city-buster
Brighter than the sun at midday,
Blazed across the dome of heaven
Toward its final destination
In the Guinness Book of Records.
They declared the problem over!
The computer guys had solved it!
For their codes had proved the cuprates
Were indeed the Hubbard model,
And that’s why the stuff conducted.
Thus there was no urgent reason
To pursue the matter further!
One could zero out their budgets
With no loss to human knowledge
And, in fact, perhaps improve it
Since this money was incentive
To continue calculations
That were clearly unimportant
And report them in the journals
Thus just adding to the clutter.

Hiawatha, now much wiser
Through his labors as a scholar
And, quite frankly, some maturing
Watched these things unfold before him,
As he had on past occasions,
But this time with eyes wide open
And was filled with understanding.
It was not a happy moment,
For it meant that his own judgement
As to what was good and worthy
Had been faulty from the outset,
Something for which he must answer.
But instead of indignation
And a passion to get even
That he might have felt when younger
Hiawatha, deep in thinking,
Found himself consumed with sadness.
He was not the only victim,
For the guys who manned those robots,
And were heroes of the cuprates—
For through focussed dedication
They had stumbled on the answer
That the models were unstable
And did *not* describe the cuprates,
Since a modest perturbation
Would profoundly change their nature—
Were about to have their triumph
Snatched from them by clever scoundrels
Who, pretending to befriend them,
Would then redefine their output
To mean something that it didn’t,
Thus protecting their investment,
But, of course, destroying others.

**VII. HIWATHA’S LAMENTATION**

Hiawatha’s knowing sadness,
Like the darkening at twilight
Or a gathering storm in winter,
Slowly gained in strength and deepened
As he spent time in reflection,
Working through the implications
Of the things that he had witnessed
For the cause of noble science
That thus far had so beguiled him.
It would simply not be manly
To pretend he wasn’t guilty
Of ignoring frequent warnings
That the needed path to nature
Was obscured or nonexistent.
It was clear that he’d been foolish
To have bought this awful fiction
And that blame must fall quite squarely
On himself and not on others.
But this candid *mea culpa*,
Made in silence where it mattered,
While it comforted his conscience,
Did not quite assuage the wounding,
For it begged the nagging question
Of how they could have succeeded
In hoodwinking all the people
For so long without some doubting.
It was simply not an option
To presume these guys were stupid,
Since the instruments they dealt with,
Often built by hand from nothing,
Needed great sophistication
To deploy and mine for data.
There was clearly something larger
And extremely fundamental
Working in the group dynamic
That involved access to funding
And the policy of journals
And the need to service markets
And the mythos of the subject
One must use to make a living
That these crooks had first deciphered,
Then reduced with understanding,
Then usurped to do their bidding.

Hiawatha, turning inward,
Thought for weeks about this problem
During which he was obnoxious
Due to his preoccupation.
But at last he got an answer
That made sense and was quite simple,
Thus withstanding Occam’s razor,
So he thought that he believed it.
When he’d set out on his mission
He had understood the challenge
Of the mastery of nature
But not basic economics
And the fact that art and science
Both require sacrifices
Of a clear financial nature
That one sometimes just can’t handle
Nor, in fairness, should one do so
Since a good guy pays the mortgage
And supports the kids in college
And the other things a body
Has to do to keep the lights on.
But, in fact, the compromises
That one makes as part of living
Such as saying what one has to
For maintaining healthy cash flow
Often toss big monkey wrenches
In the fine machine of science
And can stop it altogether
In conflicted situations.
Then the body, badly weakened,
 Barely able to keep breathing,
 Gets exploited by diseases,
 Such as villains lacking scruples
 Who descend on it like termites
 To a house that’s been neglected,
 Wreaking terrible destruction
 On the lives of those affected.

The conclusion of this story
Is well known from all the textbooks,
Hiawatha never wavered
In his deep respect for physics,
But he came by this adventure
To the deeper understanding
That to get things done that mattered
Often was a social question,
Not just logical abstraction,
And, as well, a part of nature,
Just the thing he thought he’d hated
And had thrilled at desecrating
As a tender freshman student
In the little private college
By the shores of Gitchee-Gumee.
It was true that all the creatures
Living in those swamps and woodlands
Generated lots of pooping,
But then so did real people,
And the people poop was stronger,
So that one could not ignore it.
But one really would not want to,
For the lesson of the cuprates
Was that lack of understanding
Of these basic group dynamics,
Was a recipe for failure
Since they were the central issue

For most things that were essential.

Thus the mighty Hiawatha
Turned his mind to other problems
Such as how to use resources
That were his by luck and birthright
Through the power of his father
Which he’d been inclined to squander,
But now realized he shouldn’t.
Thus he studied like a madman
To acquire the skills of statecraft,
Such as how to plan a project,
How to give effective orders,
How to make sure they were followed,
How to get things done with meetings,
And to leave the money grubbing
Up to folks his father hired
Such as all those gifted spin docs
Who created key revisions
Necessary for his image
To be something people honored.
Thus the pain of too much sliding
On the ice in dead of winter
In an inexpensive loincloth
And his other misadventures
Got removed, as did the cuprates,
From his long official story.
But the memory persisted
And it helped to make him wiser
For, of course, as he got older
He had many bad encounters
Not so different from the cuprates.

But whenever he was troubled
With a problem that would vex him
He would cheer himself by thinking
Of the special room in Hades
Into which these happy people
On account of their transgressions
Would be ushered when they bagged it
And be stuck in there forever,
Forced to listen to each other
Giving lectures on the cuprates.
It would always leave him smiling.