

The Pollen Grains Are Dancing

(A Course Revue for Physics 112)

Recent studies have shown that those who have learned either to sing or to play a musical instrument will discover an improved ability to think rationally about how to solve physics problems. Therefore, here is a song that may help.[†]

1. A long time ago, in London Town
A botanist, Mr. Robert Brown
With a microscope, he searched in vain
For the sex life of a pollen grain

CHO: **The pollen grains were dancing (3x)**
What more can we say?

2. Tiny electrons spinning around
Some point up, some point down
It's a probabilistic mechanism
But we just call it mag-a-ne-tism

Electrons they are dancing ...

3. Toss some pennies on the table
And calculate if you are able
To determine the probability
Of the number of heads and tails you see

The pennies they are dancing ...

4. Take a box of volume V
Fill it with gas up to pressure p
Multiply: p times V
What do you get? NkT

The molecules they are dancing ...

5. It's a beautiful day, the sky is clear
It's time to consider our atmosphere
For the isothermal model, as we shall see
The pressure drops off exponentially

The atmosphere is dancing ...

6. The atoms play a little game of chance
That's how they know when to dance
We now know that their solution
Is the Maxwellian Distribution

The atoms they are dancing ...

7. Over in the closet in the pile of dirty socks
Search and you will find an old shoe box
Make a tiny hole in the lid and you will see
A very fine example of a blackbody

The photons they are dancing ...

8. At length we dealt with the Second Law
In Calvin's words: it's "Yakka foob mog.
Grug pubbawup, zink watoom gazork.
Chumble špuzz": to pump heat you gotta work

The chumbles they are špuzzing ...

9. Pick a system that is **mech**-a-nickel
And form an ensemble that is **stat**-is-tickel
Do the **cal**-cu-la-tion **math**-a-ma-tickel
Form the functions therm-o-**dyn**-a-mickel

The integrals they are dancing ...

10. On the fourth of March when we came to class
It was time to deal with the quantum gas
When the spin is half an integer the particles will pack
According to the theory of Fermi and Dirac

The fermions they are dancing ...

11. The simplest system is a single orbital
How will it populate?—well let's ask Al-
bert Einstein, who worked it out so very long ago
With a Bengali by the name of Bose as we did show

The bosons they are dancing ...

12. At last we met with mister van der Waals
His atoms are like tiny billiard balls
He cooled 'em down so we could see
That point of criticality

The billiard balls are dancing ...

13. Most of what we talked about is physical
Some of it is mathematical
Some of it of course is chemical
And some of it is biological

The pollen grains are dancing ...

(end with choruses *ad lib*.)

The amoebas they are dancing ...

The spiders they are dancing ...

The squirrels they are dancing ...

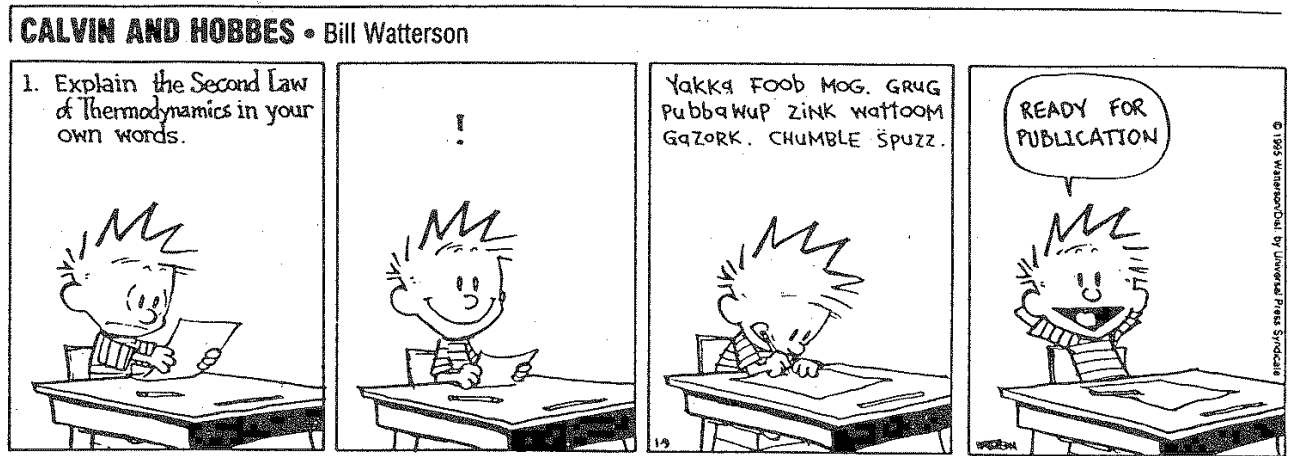
The people they are dancing ...

[†] The tune is an old Irish children's song. I wrote the lyrics. More recently the tune was used for the union song *William Brown*. In the eighth verse, the word *mog* should be pronounced "maw", and the word *špuzz* should be pronounced "schpuzz". The Bengali way to pronounce "Bose" (eleventh verse) is "Bōsh", with the "o" long, as in "both".

– Peter Scott, November, 2000

A long time a-go in Lon-don town, a bot-an-ist, mis-ter Rob-ert Brown, with a mi-cro-scope, he
 searched in vain for the sex life of a pol-len grain. The pol-len grains were dan-cing, the
 pol-len grains were dan-cing, the pol-len grains were dan-cing — What more can we say?

It is time to recognize and honor Calvin's contributions to physics:[‡]



Therefore, the following should be committed to memory:

Statements of the Second Law of Thermodynamics

Clausius (1850): Heat cannot, of itself, pass from a cooler to a hotter body.

Kelvin (1851): It is impossible by means of inanimate material agency to derive mechanical effect from any portion of matter by cooling it below the temperature of the coldest of the surrounding objects.

Kittel (1980): If a closed system is in a configuration that is not the equilibrium configuration the most probable consequence will be that the entropy of the system will increase monotonically in successive instants of time.

Calvin (1995): Yakka foob mog. Grug pubbawup zink wattoom gazork. Chumble spuzz.

This pdf, along with an mp3 sound file, is available at <https://scott.physics.ucsc.edu/songs/pollen/>.

[‡] CALVIN AND HOBBS ©1995 Watterson