

# Max The Demon Vs Entropy of Doom : Explaining Thermodynamics through Fiction and Humor

Auerbach, Assa<sup>(1)</sup>, Codor, Richard<sup>(2)</sup>

<sup>(1)</sup>Physics Department, Technion, Israel

<sup>(2)</sup>Loose Line productions, Brooklyn, USA.

The public is quite ignorant about the true meaning and importance of Energy, Entropy, and the impact of the second Law of Thermodynamics on our environment. These topics are only covered in advanced undergraduate and early graduate courses for physics majors, but early exposure to these concepts is quite possible. « Max The Demon Vs Entropy of Doom » is a comic book which aims to fill the gap, and explain these concepts without using high level mathematics.

Since the average non-physicist is afraid of formal explanations, we try a novel approach: *Teaching through a fictional superhero adventure story*. Max, a character based on the mythical Maxwell's Demon, is sent on a mission to Earth to stop environmental calamity. First, he must learn the essential laws of thermodynamics from some of the historical giants of science, so he can understand what is entropy and reduce its devastating effects. Along the way, there is suspense, villainy and near catastrophe, leading to a surprising and thought-provoking conclusion. Early viewing by colleagues and their teenage children has found the book to be attractive and beneficial to young readers with affinity to comics and to thought provoking notions. We believe that this approach might help many readers overcome a widespread aversion to the difficult but ultimately exciting scientific subjects.

Key words : Graphic Novel, Thermodynamics, Entropy, Information

## Motivation

This graphic novel aims to teach basic notions of thermodynamics and statistical mechanics to lay persons, and especially their relevance to environmental issues.

Our audience would be curious readers, without prior knowledge of physics beyond very basic mechanics, between ages 13 to adults. Even for the physics educated, the book will provide an intriguing and entertaining read.

Scientific graphic novels can be classified into two main classes:

- (i) Biographies, (e.g Apostolos, D., Papadimitriou, C., 2009), and (Ottaviani, J., 2011).
- (ii) Illustrated Courses (e.g. (Gonick, L., Huffman, A. 1991)). The second class, appeals mostly to a select group of motivated readers, with a strong interest in the subject matter.

Thermodynamics has a reputation of being a very hard subject, although some great popular books have been written for the scientifically trained (Von Baeyer, H.C. 1991). A straightforward "course book on thermodynamics", even if illustrated nicely, would put off most readers. We came up with a different approach to lure the reader, as follows.

The book is disguised as a suspenseful and humorous superhero adventure story. To follow the plot and the trials of our hero, Max the Demon, the reader will be drawn to understand the meaning of heat, statistical laws of Nature, and information.

## Who is Maxwell's Demon?

"Maxwell's Demon was invented by James Clerk Maxwell in 1871, as an imaginary "being" whose ability to sort microscopic elements of a system negates the famous Second Law of Thermodynamics, and allows Entropy to be reduced in a closed system. It was Maxwell's ingenious thought experiment which started

several decades of debates and discussions by the most notable physicists of the twentieth century. The paradoxical ability of the Demon to break the Second Law was resolved in a surprising way when the deep connection between Entropy (a quantity related to heat and temperature) and Information (a quantity related to measurements and communication) was discovered. This is explained in simple terms in our book, as the plot unfolds.

A known reference to this subject is "Maxwell's Demon: Entropy, Information, Computing" by (Leff, H.S., Rex, A.F., 1990).

## Abstract Of The Story

The story is a "tongue in cheek" adventure of a superhero, named "Max the Demon". Earth is being destroyed from over production of entropy, that is to say, too much pollution from burning fossil fuels, and global warming. Max is sent by his commander, Sir Bio, from Planet Tachyonia, to save the earth. How will he do it? Can he do it without publicly violating the laws of physics? These questions get answered in a surprising way at the end of the story. Max arrives on earth with superhuman vision capabilities, but without knowledge of physics. The first part of the book sets up Max's education.

His entertaining encounters with some of the great physicists of classical thermodynamics, (Rumford, Carnot and Boltzmann), teach Max, (and the reader), about the Second Law and Entropy.

In the second part, Max is aided by a young and energetic tattoo-artist-turned-physicist named Julie Calore. Julie and her students build a

small power plant, which uses Max's superhuman skills to produce electricity for free, using the heat of ordinary tap water. This, of course, is in blatant violation of the Second Law. An evil minded General of a foreign dictatorship (Ergodistan), tries to use Max's design to separate nuclear isotopes. A massive explosion results, and Max is shamefully called off his mission by Sir Bio: he has violated the Second Law in public.

In the third part, Max drifts west to meet his spaceship. On the way he hitches a ride with Richard Feynman and his dog Qubit. Feynman explains to him why Ergodistan's isotope plant failed and exploded. This requires him to explain the connection between entropy and information. Now Max (and the reader) understand why Max's entropy reducing actions cannot be implemented by computerized mechanical devices, no matter how small and efficient they are. Max meets up with Julie Calore in Las Vegas. An exciting evening in the gambling halls ends up with a car chase and crash just as the space ship lands.

In the final scene, (without giving a spoiler) it turns out that Max's mission was a success after all.

## Production

We have been strongly inspired by the success of "Logicomix" by Doxiadis and Papadimitriou (Apostolos, D., Papadimitriou, C., 2009), who produced a fascinating graphic novel. It is in the class of biographical books, but it also succeeds in explaining quite complex philosophical and mathematical issues which occupied Bertrand Russell during the early 20th century. The high quality of graphic art, and the easy-to-readdiscussions, are crucial factors which make that book accessible to a wide audience.

Our vision was a similarly well produced, high quality colored graphic novel. Like Logicomix, we hope it would be sold in regular bookstores, and online, and that it would also be acquired by high school and college libraries, as supplemental reading for students. Appended to end of the graphic novel, there is a text supplement, which adds the pertinent historical, biographical, and physics details and clarifications for the more advanced readers. A list of references to authoritative textbooks, and websties is included.

## References

- Apostolos, D., Papadimitriou, C.,(2009) *LOGICOMIX: an epic search for truth*, Bloomsbury Publishing, NY.
- Auerbach, A., (1994), *Interacting Electrons and Quantum Magnetism*, Springer-Verlag, NY.
- Gonick, L., Huffman, A. (1991) *The cartoon guide to physics* , HarperPerennial, NY.
- Leff, H.S., Rex, A.F., (1990) *Maxwell's demon. Entropy, information, computing*, Adam Hilger, Bristol.
- Ottaviani, J., (2011), *Feynman*, Macmillan, NY.
- Von Baeyer, H.C., Von Baeyer, H.C., (1991) *Warmth disperses and time passes: The history of heat*, Modern library, NY.