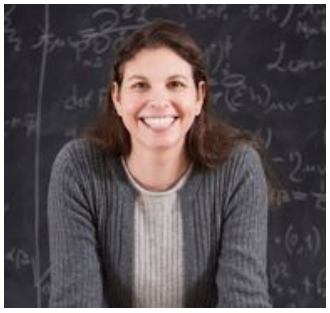
The beauty of falling. A life in pursuit of gravity. *Claudia de Rham*. Princeton University Press, 2024 (232 p.), isbn: 978-0691237480 (pbk)





Claudia de Rham

Claudia de Rham is a cosmologist who has devoted her life to the study of gravity. She liked deep sea diving but her dream was to become an astronaut. She became a pilot, and subscribed for the ESA call to be tested as potential astronaut. She made it to the third round until a newly developed test discovered that she had a risk op latent tuberculosis. In her professional career she studied and worked as a theoretical physicist at different universities. Her expertise is gravity, which explains the title of this book in which she introduces the reader in a very accessible way to the curved spacetime of general relativity, black holes and the future of the cosmos. She starts each chapter with some parallel events in her personal life and her attempts to become an astronaut.

Although her work is mainly theoretical involving the solution of complicated equations, here she graciously avoids the technicalities and explains the laws of physics with very accessible analogies from everyday life. Gravity is a force that acts on everything that has a mass. Like massless photons transport electromagnetic information as light waves, and at a subatomic level the messengers for the strong nuclear force are massless gluons and for the weak interaction we have the massive W and Z bosons. That the photon and gluon are massless can be explained by the detection of the massive Higgs boson in 2016. All this is according to the current standard model of particle physics. The major problem haunting cosmology today is how to incorporate gravity into this model. It is natural to introduce for gravity, some hypothetical messenger called graviton that is transported in waves which de Rham calls gravitational light waves or glight. From several computations as well as from experiments, it follows that these waves are many orders of magnitude longer than for example light waves, and they are so weak that it takes gigantic masses like binary stars or two black holes that are embracing each other in a swirling dance just before they collapse. These are the gravitational waves that could be observed recently in 2017 by the LIGO (Laser Interferometer Gravitational Wave Observatory). It is generally assumed that the graviton is massless and that the speed of glight is the same as for light.

What is the universe heading to? Shortly after the Big Bang, dark matter was and still is everywhere. Some of it has been condensed to form massive stars and galaxies. The Big Bang blew space apart in a gigantic inflation that slowed down a bit. One would expect that the pull of gravity would slow down the expansion and eventually bring it to a stop. The equations however predict that our universe is expanding at an increasing speed and will end in a vast empty cold and dark space. This is believed to be confirmed by experiments. This can only be explained by dark energy. The problem with gravity as it is known from general relativity theory is that it breaks down when the curvature becomes too large or even infinite as at the center of a black hole, creating an unacceptable singularity.

As a solution for this incompatibility, de Rham and her colleagues proposed to let the graviton have some tiny mass, which would explain a lot, but, since everything is related to everything else, this also distorts some of the generally accepted beliefs, leading to toxic messages on the social platforms threatening her to retreat their paper. So she dedicates this book to her trolls, giving arguments to show that a massive graviton is not completely senseless and should be investigated. To defend her mathematical approach she gives the analogy: π can be defined, measured or computed as the circumference of a circle divided by the diameter, or as the weight in grams of the water in 3 quarters of a spherical balloon with radius 1 cm, or by the Gregory-Leibnitz series. However if the circle is plotted on a curved surface, or taking gravity of the balloon into account, the first two methods need adaptation, while mathematics remains always valid everywhere.

Adhemar Bultheel