WHY DO WE SPEAK OF LAWS OF NATURE?*

Jörg Hüfner

Theoretical Physics, University of Heidelberg
Philosophenweg 16, 69120 Heidelberg, Germany
joerg.huefner@tphys.uni-heidelberg.de

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The concept of a *law of nature* has origins which date back several millennia. The idea of a divine law-giver is found in the Mesopotamian, Jewish and Christian religions. Hellenistic scientists did not speak of *laws*, but used mathematical terms to describe their discoveries. The religious and scientific traditions would not converge, however, until Descartes and Newton laid the foundations of modern science and shaped the modern concept of a *law of nature*. It seems that during the 20th century this notion gradually comes out of use at least in the scientific language.

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1. Introduction

Law is an important concept in religion, state affairs and the sciences. When I discussed the different meanings in the various fields with Rüdiger Bittner, a philosopher from Bielefeld, he surprised me with the statement: "What is called a law of nature is not properly a law". He then explained his position by saying: "A law is something against which the thing subject to it may recalcitrate, and that does not happen with natural objects". For a scientist, a law is related to an observed regularity in nature, and therefore Bittner's criterion for delimiting the concept of a law sounds strange, indeed. Why then does Bittner claim that the juridical or religious concepts of law define, what is a law? Upon further reflections the situation became even more confusing: Why does one use the same word *law* for two rather different concepts, for the concept *law of nature* and for the concept of *law* in the juridical or religious domains? When talking to colleagues about my confusion, they suggested that I go into history and study where the notion of a law of nature comes from. In the following I will briefly report on some of my findings. More details may be found in the land mark paper by Zilsel [1] and in a monograph by Hampe [2] .

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We must first delimit the spheres of thought, in which the word *law* has principally been engaged, and we must simultaneously examine just how the word has functioned in each of these realms. The territories with which we shall be concerned are the religious, the juridical and the scientific ones. Now, religious and juridical laws are prescriptive, and apply to the sphere of humans and their society, while the laws of nature are descriptive-predictive and apply to the material world. Thus, the former two types of law generally require a law-giver, or law-givers, along with a targeted group, who will be subject to the decreed law or laws, where as for the latter category, in the modern world at least, it is possible to conceive of these natural laws independent of a specifically defined law-giver, and with an audience that is quite simply the universe, such as we know it. In any case, today we consider these distinctions as quite fundamental, and therefore the use of one word for two rather different objects is a source of confusion. In ancient times, like those of the Mesopotamian civilization for example, however, these differences were less important, and the common aspect, namely, that law creates and describes order, was more significant. Therefore, it is less surprising that they applied etymologically related words to natural regularities, religious commands and legal statements.

2. Religious tradition: a divine law-giver

The regular motion of the sun, in its daily and yearly rhythms, was evident to every Mesopotamian, and was for him the most important proof of an order in creation. The guardian of all creation was the sun god, Shamash, who was also responsible for maintaining the natural order. He received the byname *mushteshiru*, meaning *the one who rightly guides*. The word *mushteshiru*, though, has the same root as the word *shuteshuru*, which relates to the legal sphere of Mesopotamian life. For instance, *mushteshiru*, literally meaning *to put and keep in good order*, describes the work of a judge and then means *to set aright, to provide justice*. But the same word also applies to the process of legislation, like the one of the famous law-giver Hammurabi from the second millennium BCE [3].

So, while the Mesopotamians did not speak precisely of a law of nature, or the like, the words they used to describe, on the one hand, the fixing of a regularity in the natural world, and, on the other hand, the humanly-driven legal regulation of mankind's socio-political world, were etymologically related. While for us this double usage tends to be a source of confusion, as indicated in the introduction, it was natural for the people of Mesopotamia, since they believed in an all-embracing cosmic order. The double usage of one word for regularities in nature as well as for ritual, moral and legal prescriptions starts in Mesopotamia and continues in the Jewish, ancient

Greek and Christian religious traditions. Given the frequent — peaceful and belligerent — contacts beween the civilizations in the Near-East, the similarities in world view do not seem accidental.

Law is a concept absolutely central to Judaism. God is the divine law-giver, the source of all moral and ritual laws. However, as Zilsel puts it, "Since God in addition is the creator of the world, it is easy to understand that the idea arose of his not only having given the moral and ritual laws to the people, but also having prescribed certain prohibitions to the physical world. In a description of God's power and omniscience, Job 28, 26 says that God made a law for the rain" [2]. The Hebrew word *chok* is used for law in Job 28, 26. *Chok* goes back to the verb *chokak*, which means to *engrave*. In the Old Testament, this word is mainly used for moral, as well as ritual laws given by God, and occasionally for natural phenomena, like in the quoted verse from the book of Job. The Vulgate, a widely used Latin translation of the Old Testament from the end of the fourth century CE, translated the verse Job 28, 26 with *ponebat legem* (he laid down the law). The translation of *chok* with *lex* would thus seem to connect the Jewish and Christian traditions to the Latin diction. That such a choice of words might raise thoughts of the Roman legal system was, perhaps, inevitable. But, that was probably not the intent in opting for this word here.

In the Mesopotamian and Jewish traditions the general order in nature was not governed by permanent and unchangeable laws. For instance, the story of Noah which appears in both traditions was a reminder that the whole cosmic order can be endangered by human actions. Nor were specific aspects of nature, like draughts, perceived as being immutable. The role of the Gods or the God was not reduced to the creation of the world, but rather included a permanent and active engagement in the world of natural and human affairs. God was both, creator and lord of the world. When there was draught, people prayed to God in order to please him because he had the power to change the conditions of the weather. This idea of God's omnipotence was not restricted to the Mesepotamian and Jewish religions, however. It was a widespread belief in the religions of the old world.

Since God or the Gods were believed to interfere with the natural course of things, phenomena in nature were observed in order to discover divine intentions, rather than to discover the immutable laws of nature. Nevertheless, in their pursuit of divination the Mesopotamian scientists discovered important regularities in nature and thus laid the foundations of scientific astronomy.

Christian theology is primarily based on the texts of the Old and New Testaments, but it has also taken up aspects of the thinking of the people who adopted the Christian religion, and in particular, Christianity borrowed from the philosophical traditions of Hellenism. In my rather eclectic approach

to the history of the concept of law, I choose only one example from the Christian tradition and quote from the church father Augustine (354–430), who had a lasting influence. He stands in the philosophical tradition of the Stoa and identifies the rather unspecifically defined divine law-giver of the Stoa with the Christian God and marks out an eternal law. "The truly eternal law is the Holy Spirit or the Godly will, which commands the natural order to be preserved and forbids it to be perturbed". The eternal law is an important new concept in the religious tradition, because God's role in the natural order is restricted to that of a law-giver: After creation, God no longer interferes with the natural processes. The divine laws of nature are immutable — a necessary condition for any scientific research. This position remained unchanged in the theology of the Middle Ages.

3. Scientific tradition: terminology from mathematics

If one had to date the birth of science as we understand it today, one might choose the third century BCE, because of the ground breaking works by the astronomer and mathematician Aristarchus of Samos (around 270 BCE) and by the physicist, mathematician, and engineer Archimedes from Syracuse (287–212 BCE). Both emphasized the importance of quantitative observations. At the same time, they significantly contributed to the progress of mathematics, whose foundations had already been laid by Pythagoras (6th century BCE) and by Euclid (around 300 BCE). Empirical investigations and the development of mathematics complemented each other beautifully, after it had been realized that the empirical findings could be expressed in mathematical terms *e.g.* in relations between numbers. It is therefore not an accident, but rather a necessity, that great physicists and astronomers often were also great mathematicians. The amazing fact, that physical regularities can be expressed in mathematical terms, also influenced the language, in which scientists were talking about their findings. Increasingly they preferred a mathematical language, because they found this language to best fit their observations.

In classical antiquity only three physical laws were correctly known, the mechanical law of the lever, the optical law of reflection and the hydrostatic law of buoyancy. All three laws were known to Archimedes, but he never used the term *law of nature*. "Although Archimedes, by far the most eminent physicist of antiquity, certainly verified all three laws by experiments (the law of buoyancy was even discovered by him experimentally), he does not explain them empirically. He rather follows the deductive method of Euclid, starts from postulates, and deduces and proves his physical statements, as if they were mathematical theorems. [...] Archimedes speaks as little of the *law of buoyancy* as Euclid speaks of the *law of Pythagoras*" [1]. For Archimedes and

his Hellenistic fellow scientist, the task of science is the description of nature, relating observed phenomena to one another, preferably via mathematical relations.

Galileo (1564–1642), stands at the beginning of what we call modern science. He did careful experiments and was able to phrase his results in mathematical relations. "In Galileo's published writings the term law in the sense of law of nature occurs hardly at all. It is particularly remarkable that his famous achievements [...] *viz.* the laws of free fall, of inertia, and of pendulous motion, are never termed *laws* by Galileo himself. He instead speaks of some properties of accelerated motion, of the definition of uniformly accelerated motion, of the proportion or the rule of the acceleration of falling bodies, or the like. Laws of nature are only mentioned in a rather general context, namely in the course of a discussion of the mutual relation between the knowledge we may obtain by studying the Holy Scripture, and that obtained by studying the book of nature" [4]. For Galileo the universe is written in the language of mathematics, *i.e.* the apparent mathematical structure of physical laws reflects a fundamental structure of nature. Without a solid knowledge of mathematics nobody is able to read the book of nature.

4. Descartes and Newton

The two scientists, Archimedes and Galileo and their fellow scientists rarely used the term *law* at all, when they spoke of their scientific findings. Therefore it came quite as a surprise that René Descartes (1596–1650), Galileo's contemporary, an eminent philosopher, mathematician and physicist, declared that he has found "laws which God has put into nature" (Discours de la méthode). Furthermore, we read in his Principia Philosophiae: "And from this immutability of God some rules or laws of nature which are the causes [...] of the various motions, can be understood". Descartes reintroduced the concept of a divine law-giver as the origin of the laws in nature. The locutions *rules or laws* indicates that Descartes was not quite sure about the proper wording. It is not clear to us, whether *rule* (*règle* in the original text) is just an expression for a regularity which has not yet the status of a law, or whether it is a more neutral even mathematical term for a law in the tradition of earlier scientists. Mathematics was certainly a major part of Descartes' system of thought. "Descartes took his concept of laws of nature from the mathematical tradition, but recognized that he could not export it to the domain of physico-mathematics, to play a causal role, unless he could show that these laws were underwritten by God" [5]. Descartes had a tremendous influence on the further development of philosophy and science. We only give two examples, Spinoza and Newton.

Baruch Spinoza (1632–1677) agreed with Descartes and with the earlier philosophical tradition in that the laws of nature are immutable and necessary. However, being a pantheist Spinoza did not accept the notion of a divine law-giver. For him the locution *law of nature* is only to be understood as a metaphor. In this respect, most modern scientists would side with Spinoza and not Descartes.

Isaac Newton (1643–1727) was one of the giants in physics and shaped modern science in many respects. He was a very religious man and also deeply influenced by Descartes. Newton's fundamental book "The Mathematical Principles of Natural Philosophy" (1787) became the "bible" for generations of physicists after him. This book begins — after some definitions — with a chapter called "Axioms or laws of motion". This is a very interesting wording, since it brings two traditions together, the mathematical one in the use of axioms and the religious one in speaking about laws. In this book, Newton shows that the magnificent theory of mechanics can be obtained by mathematical derivations from only three fundamental laws of motion together with the law of gravity. These laws play the role of axioms in a mathematical theory. They are so fundamental, that their origin can only be found in God. Starting from these laws, Newton derives propositions and theorems, but not laws. For instance, Newton does not call Galileo's or Kepler's results laws, since they follow by mathematical derivation from his fundamental laws.

5. After Newton

Newton had a tremendous influence on the generations of physicists after him — in physics, methodology, and language. Yet, his successors were not as careful in their wording as he had been. For instance they followed him, when they called the fundamental statements in the theory of heat the *three laws of thermodynamics*. But the notion law is also used for minor regularities, like *Ohm's law*, which describes the relation between the electric current and the voltage across an electric resistor. When the locution *law* was used after Newton, it was mostly a as metaphor and not because the speakers had in mind a divine law-giver.

While there are many examples for the use of *law* in the 18th and 19th centuries, a shift seems to take place during the 20th century. The term *law* comes out of use in the professional language. For example, one never speaks of the *law of relativity*, but rather of the *principle* or of the *theory of relativity*. The reasons for this shift are not clear to me. They may be connected with the fact that Newton's physics looses influence. Today's scientists mostly use the locution *laws of nature* when they talk about their findings to a broader public.

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