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MAXWELL'S DEMON AND INTERACTIONISM

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Abstract. *Maxwell's demon is an imaginary being invented a century and a half ago by James Clarke Maxwell in order to illustrate the statistical nature of the Second Law of thermodynamics. It helped us reach a better understanding not only of that law but also of the relationship between statistical physics and thermodynamics. Since the 1910's it has caused a flood of papers of scientists who have tried to save the Second Law from the threat of the demon and hence preclude the possibility of perpetuum mobile of the second kind. Nowadays, it helps us better understand the possibility of constructing an interactionist model of mental causation manifested through the violation of the Second Law by the mind.*

Key words: *The Second Law of thermodynamics, statistical mechanics, Maxwell's demon, interactionism, mental causation*

1. INTRODUCTION

A century and a half after its birth, Maxwell's demon is still an inexhaustible source of both inspiration and worry for the physicists. An apparently endless stream of books, scientific papers, and editorials on this intriguing topic, which flows through the scientific world since the beginning of the last century, keeping an army of physicists on their toes, is a lasting testimony of the importance of Maxwell's famous thought experiment. And it is fittingly so because the purpose of the conception of Maxwell's brainchild was to demonstrate that one of the most important laws of physics – the Second Law of thermodynamics – cannot be strictly true. In fact, Maxwell used the actions of his demon as an illustration of his interpretation of the Second Law, which is much weaker than the one accepted by most physicists.

The broadly accepted version of the Second Law is probabilistic in its nature. It claims that there can be no process in which heat is consistently transferred from a colder to a warmer body unless a compensating increase of entropy is produced somewhere in the system. The fluctuations which occasionally manifest themselves in the opposite

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direction are essentially unpredictable and inconsistent. Such fluctuations cannot be used to realize the perpetuum mobile of the second kind: a contraption that could transfer heat from a colder to a hotter body. On the other hand, Maxwell's statistical interpretation of the Second Law, corroborated by the thought experiment which is the topic of this discussion, is significantly weaker. He maintains that the validity of the core concepts implicit in the law, and thus the law itself, is restricted to situations in which an observer has no ability to manipulate individual molecules and is forced to deal with a large number of molecules by using statistical concepts. Therefore, Maxwell's statistical formulation of the Second Law introduces an essentially subjective feature into the laws of thermodynamics. It implies that the description of a thermodynamic system depends on our knowledge of the system and on the means available for gathering information about the system and manipulating it. No wonder, then, that an outpour of papers ensued in an attempt to save the Second Law from the demon and show the futility of its endeavor.

The structure of this work is as follows. In section 2 a brief overview of the Second Law of thermodynamics and the thought experiment concerning Maxwell's demon is given. An overview of the ensuing attempts to exorcise the demon, as well as the apparent futility of these attempts, is outlined in section 3. In section 4, I demonstrate that the subjective feature of central concepts of thermodynamics implies an unavoidable role of an intelligent observer in the interpretation of its results. Inevitably, the parallels emerge with the mind-body problem – one of the central conundrums of modern philosophy. I argue that this state of affairs opens the way to the development of an interactionist model of mental causation, based on the assumption that actions of the mind on body emulate the actions of Maxell's demon, in that mental causation manifests itself without violating any of the conservation laws, but at the cost of violating the widely accepted, probabilistic version of the Second Law of thermodynamics. Finally, in section 5 I conclude with a brief summary of the discussion.

2. The Second Law of Thermodynamics and Maxwell's Demon

The Second Law of thermodynamics, in the Clausius's formulation, requires that heat can never pass from a colder to a warmer body without some other, connected change occurring at the same time. Clausius concludes that the entropy never decreases during spontaneous processes and that, consequently, the entropy of the universe tends to a maximum. The equivalence of Clausius's formulation with numerous other statements of the Second Law[1] can be easily deduced.

The ascent of the statistical mechanics in the 19th century brought about the need to reinterpret the results of the classical thermodynamics in the light of the kinetic theory of heat. Since the heat was no longer seen as a fluid flowing from a hotter to a cooler body but as a result of the statistical averaging of the molecular velocities, it became apparent that the inferences of the classically stated Second Law could no longer be regarded as exactly true. The validity of the Second Law is understood in a statistical sense and is provided by the postulate of statistical mechanics that all microstates are equally probable if the system is in the state of equilibrium. This means stat the Second Law holds only on average, because fluctuations in the system are capable of causing local, temporary

[1] As an American physicist, philosopher and Nobel Prize winner P. W. Bridgman once famously said, "there have been nearly as many formulations of the Second Law as there have been discussions of it."

increases of entropy and other physical quantities, and thus local violations of the law. From the statistical analysis of these variations, such as the one given in Landau & Lifshitz (1969), one easily deduces that the relative statistical variation is proportional to $1/\sqrt{N}$, where N is the number of particles in the system. For many-particle, macroscopic systems in which the approximation $N \to \infty$ is valid, this statistical variation is negligible, which means that the behavior of these systems unfolds in accordance with the Second Law with almost no exceptions. If, on the other hand, the system contains a small number of particles, there can be significant statistical deviations, i.e. fluctuations in the system. This situation may render the Second Law inapplicable, because classical thermodynamics, as a macroscopic theory, has no mechanism for dealing with such situations.

In 1874, William Thomson (later Lord Kelvin) formulated an objection to the Second Law which, after Loschmidt reinvented it two years later, became known as Loschmidt's reversibility paradox. Basically, it is the objection that irreversible processes should not be produced by the time-symmetric microdynamics governed by deterministic time-reversible laws. In a letter sent to John William Strutt (later Lord Rayleigh) in 1870, four years before Thomson's objection, Maxwell expressed his reservations concerning the Second Law. For the first time he offers a rudimentary idea of the demon,[2] and then draws the following 'moral':

> The 2nd law of thermodynamics has the same degree of truth as the statement that if you throw a thimbleful of water into the sea, you cannot get the same thimbleful of water out again (Strutt, 1968, p. 47).

Maxwell presented his view of the Second Law in the *Theory of Heat* (1871), where the demon was introduced to the public for the first time. He maintains that the Second Law can only be applied to macroscopic, many-particle systems, i.e. masses of matter, and not on separate molecules constituting the system. In order to illustrate the statistical nature of the law, Maxwell conceives a being whose senses could follow every molecule in a vessel full of gas at a uniform temperature and proceeds:

> Now let us suppose that such a vessel is divided into two portions, A and B, by a division in which there is a small hole, and that a being, who can see individual molecules, opens and closes this hole, so as to allow only the swifter molecules to pass from A to B, and only the slower ones to pass from B to A. He will thus, without expenditure of work, raise the temperature of B and lower that of A, in contradiction to the Second Law of thermodynamics.
>
> This is only one of the instances in which conclusions which we have drawn from our experience of bodies consisting of an immense number of molecules may be found not to be applicable to the more delicate observations and experiments which we may suppose were made by one who can perceive and handle the individual molecules which we deal with only in large masses.

[2] The term "demon" was coined not by Maxwell himself, but by William Thomson.

> In dealing with masses of matter, while we do not perceive the individual molecules, we are compelled to adopt what I have described as the statistical method, in which we follow every motion by the calculus (Maxwell, 1871, pp. 308-309).

Maxwell drew a couple of important morals from this consideration. The first of them was that the 'learned Germans', as he used to call the distinguished members of the German school of the 19th-century statistical physics and thermodynamics, above all Boltzmann, were wrong to believe that the Second Law can be deduced from statistical mechanics and that the Second Law is nothing more than the Hamiltonian principle. Bolzman conceded the point after a long and unsuccessful struggle to prove that equivalence. The second moral was that the distinction between the dissipated energy and energy available for work rests on anthropocentric considerations and depends on our knowledge of the state of the system. Put another way, this distinction is means-relative (Myrvold, 2011): it depends on the means available to the observer to gather information about the system and to manipulate it. Maxwell writes:

> [T]he idea of dissipation of energy depends on the extent of our knowledge. Available energy is the energy which we can direct into any desired channel. Dissipated energy is energy we cannot lay hold of and direct at our pleasure, such as the energy of the confused agitation of molecules which we call heat. Now, confusion, like the correlative term order, is not a property of material things in themselves, but only in relation to the mind which perceives them. [...] [T]he notion of dissipated energy would not occur to a being who could not turn any of the energies of the nature to his own account, or to one who could trace the motion of every molecule and seize it at the right moment. It is only to a being in the intermediate stage, who can lay hold of some forms of energy while others elude his grasp, that energy appears to be passing inevitably from the available to the dissipated state (Maxwell, 1878, p. 221).

In this way, Maxwell introduced subjective elements into the interpretation of the laws of thermodynamics. This state of affairs produced a lot of confusion among physicists, because if concepts such as heat and work depend on our state of knowledge, then so do entropy and its difference between two equilibrium states of a system. In other words: work, heat, and entropy are nothing but anthropomorphic concepts. For an intelligence embodied in Maxwell's demon, capable of tracking the motions of individual molecules, there would be no distinction between heat and work. Thus, the Second Law would lose its meaning, along with the concepts it is related to. However, from the perspective of an outside observer, whose knowledge of the system is limited and who, consequently, differentiates between heat and work, the demon's actions would represent an apparent violation of the Second Law.

3. EXORCISING THE DEMON

Knowing all this, it is of little wonder that an army of physicists, starting from the early 20th century, devoted their energy and enthusiasm to the noble endeavor of exorcising the demon and saving the Second Law.

The earliest attempts of this kind originated in the 1910s and consisted in the naturalization of the demon, i.e. in trying to represent it as a physical system in thermodynamic equilibrium with the gas in the vessel. The basis of this approach is consisted of Maxwell's ambiguity in presenting the demon, in the sense that it is unclear if he conceived it as an integral part of the system or an outside entity. The question is not benign, because it reduces to the dilemma if the demon is to be seen as the physical entity to which laws of thermodynamics must apply – a bunch of molecules in thermal equilibrium to be precise – or an outside intelligence. As we will ascertain later, in the former case the application of the Second Law to the demon is ensured, and no exorcism is needed. In the latter case, the laws of thermodynamics do not apply, and all the attempts to banish it are futile because no physical property can be ascribed to an immaterial agent (Averil & Keating, 1981). Anyhow, the project of the naturalization of the demon started with Smoluchowski (1912) and continued with a number of like-minded successors such as Gouy, Svedberg and others who contrived a lot of well-crafted mechanical contraptions that could simulate the actions of the demon, in trying to use molecular fluctuations to extract work from heat without the loss of energy. They demonstrated that a machine that would be able to perform such a task – the notorious perpetuum mobile of the second kind – is not possible. Smoluchowski thought that this conclusion was sufficient to save thermodynamics from the demon.

The second approach to exorcism, based on the information theory, entered the scene with Szilard's work in 1929. This approach, still popular nowadays, is based on the calculation of the entropy cost that the demon has to pay in the process of acquiring, processing and deleting the data from its measurements of molecular velocities and positions. Szilard maintained that the entropy produced by the demon in the act of measurement is more than enough to compensate for its decrease during the molecular separation in the vessel. This method, as well as the others that were based on the information theory in the ensuing decades, presupposed that the demon was a physical system in the thermodynamic equilibrium with the gas in the vessel. This is by itself sufficient, as we made sure, to provide the conclusion that the Second Law is preserved. Starting at the point at which Szilard had stopped, Brillouin (1953) calculated that the minimum entropy produced in the process of measurement, allowing the choice between n equiprobable states, is $k_B \ln n$, which means that minimal energy released into the environment of temperature T while acquiring or modifying one bit of information is $k_B T \ln 2$. Here, k_B is Boltzmann's constant. According to Landauer's principle which gained popularity a couple of decades after the original Landauer's work in 1961, the approach based on the entropy cost of information acquisition is wrong. Instead, a minimum of $k_B \ln n$ of entropy is produced during the *erasure* of information from the demon's memory.

However, in their detailed analysis of the history of exorcism of Maxwell's demon, Earman & Norton (1998, 1999) demonstrated that these efforts are misplaced for the reason which has already been discussed: if the system gas-demon is in a thermodynamic equilibrium, it is already governed by the Second Law and no exorcism is needed. If, on the other hand, the demon is understood as an intelligent agent outside of the system, "no supposition about the entropy cost of information acquisition and processing can save the Second Law from the Demon" (Earman & Norton, 1999, p. 1). In that case, a new postulate, either relating entropy and information or a general one, is needed to save the Second Law for the combined system. At present, it is not clear what this postulate could be.

To make matters worse for the proponents of the information theory approach, Zhang & Zhang (1992) gave a specific example of a time-reversal invariant and conservative dynamical system which does not preserve phase volume, whose operation violates the Second Law. Zhang & Zhang constructed their system with a membrane, which divides chambers in the experiment similar to the original Maxwell's device, acting as a force field, so that it can be viewed as purely mechanical – hence, no information theory argument can be invoked in order to save the Second Law. This indicates a serious weakness of considerations stemming from information theory: they cannot determine, in the last instance, what is *physically* possible and what is not. Only physics can be the judge of that.

The inference that the attempts to banish Maxwell's demon are ultimately invalid because they assume the Second Law as a premise if the demon is a part of the combined system, and because the Second Law cannot be applied if the demon is an intelligent agent outside of the system, is interesting enough in the context of statistical mechanics and thermodynamics. However, the intriguing ramification of these considerations to contemporary ontology is perhaps less obvious, but potentially much more important. In the next section, I will outline some aspects of this ramification.

4. An Interactionist Reinterpretation of Maxwell's Demon

Interactionism, or interactive dualism, is an ontological theory which basically maintains that there are fundamental, ontological differences between matter and mind (Robinson, 2017) and that they mutually causally interact. There are two types of dualism: substance dualism, which claims that the mental and the physical are two different substances to which particular properties are ascribed, and property dualism, according to which entities are nothing but bundles of properties, with no substrate carrying them. For purposes of this discussion, both types of interactionism equally apply; all that matters is that interactionism claims that mental properties cannot be reduced to the physical and that they are irreducibly causally efficient. These features make interactionism the polar opposite to the ontological doctrine of physicalism,[3] which claims that there is nothing over and above physical in the world.

Of course, there is no denying that mental causation exists in our world. My wish to lift a pencil is the cause of its being in my hand, and not on the table. People make decisions every second, and those decisions have clear consequences. So, to deny the causal efficacy of the mental is to postulate that all events in the mental domain can be reduced to their physical basis. This means that for every mental property or event there are physical properties to which they reduce, in case of reductive physicalism, or on which they supervene or are their realizers – if one subscribes to some of the non-reductive varieties of this doctrine. From the physicalist point of view, mental properties are either identical to the physical ones, supervene on them, or are simply epiphenomenal – which means that although they are not reducible to physical properties, they have no causal power on their own. The main cause of this conviction is the observation that the physical world is causally closed, i.e. that if a physical event has a cause at a time *t*, it has

[3] Useful introductory information about physicalism can be found in Papineau (2001), Melnik (2003), Dowel, (2006), and Stoljar (2017). For the discussion of some problems concerning the formulation of the physicalist thesis see Dimitrijević (2015).

a sufficient physical cause at a time *t* (see Papineau, 2001 and Kim, 2005). This inductive claim is known as the causal closure principle. It is usually warranted by the claim that any irreducibly mental force would cause anomalous accelerations of particles in the brains and nervous systems; the fact that physiological research in the last century and a half failed to provide evidence for such accelerations is taken as strong evidence that irreducible mental causes do not exist (Papineau, 2001).

It should be noted at this place that numerous other formulations of the causal closure principle, deviating more or less from the standard Papineau's and Kim's version which I cited, can be found in the literature. Some of them are probabilistic in nature; some refer explicitly to the laws of physics. It turned out that most of these formulations are either too week to corroborate the physicalist argument, or too strong to be able to obtain adequate empirical support. The latter case is particularly important because numerous physicalists, who boldly maintained – like Spurrett and Papineau (1999, p. 25) – that "All physical effects are due to physical causes", were forced to admit that it is not possible to support such a strong metaphysical claim empirically. However, none of these considerations affect the conclusions of this paper, because, as we will see, an interactionist is in no way obliged to accept any form of the causal closure of the physical.

The argument from causal closure principle is not conclusive since some writers argue that irreducible mental causation can be manifested not by causing anomalous accelerations in the system, but by causing redistribution of energy, momentum, and other physical properties in the system (Gibb, 2010). No non-physical forms of energy appear in this case, so that the conservation laws of physics apply; however, since the redistribution supposedly occurs with no outside force mediating that process, the violation of the Second Law of thermodynamics is a direct consequence of this causal mechanism, as first noted by Morowitz (1987). In order to perform such a feat, an immaterial mind would have to choose a specific microstate between a lot of alternatives, without expending energy either during measurement or in the selection process. This is obviously a description of Maxwell's demon. An important question, however, remained unanswered: how the mind obtains the knowledge of the state of the system if it is forbidden any expenditure of energy?

Now we see the reason for the interactionists' interest in modus operandi of the demon. The discussion clearly shows not only that immaterial mind must act like Maxwell's demon, but also that the insistence that it must obey the Second Law would negate its non-material nature and thus beg the question in favor of physicalism; for in that case, the mind would constitute a part of the composite system in the thermal equilibrium with the body, as we deduced in the above analysis of demon's behavior.

The model of mental causation suggested by Lowe (2006, 2008), one of the leading contemporary proponents of substance dualism, is construed along these lines. Lowe argues that mental causation in the neural systems of living beings is manifested not in anomalous accelerations, but in anomalous convergence of seemingly independent neural events toward particular bodily effects. He believes that such convergence is a formal property of causal trees. The opponents of Lowe's account, however, usually claim that it is unintelligible because it does not offer an elaborate account of the mechanism of mental causation in terms of more fundamental, non-causal processes and events.

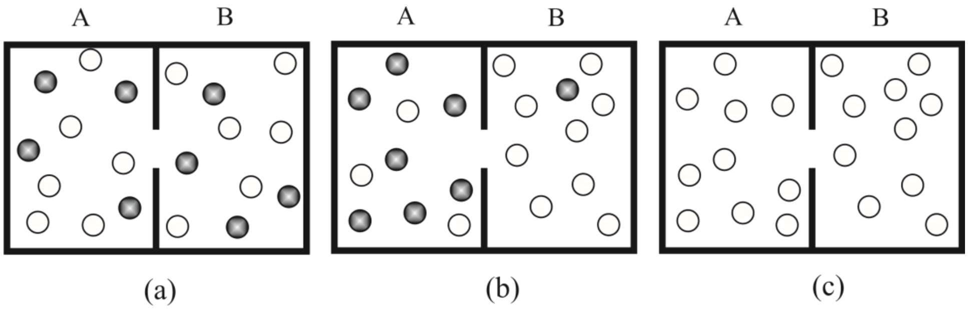

Fig. 1 Modified Maxwell's thought experiment, as an illustration of mental causation. An explanation is given in the text.

In the remainder of this section, I will use a modified Maxwell's thought experiment in order to outline the main features of a conceivable, intelligible, interactionist model of mental causation. The details of the model are worked out elsewhere; here, we are only interested in a qualitative consideration of its most important characteristics and consequences.

The closed insulated container, shown in Fig. 1, is divided by a barrier into two equal chambers, A and B. The chambers are at the same temperature and represent two equienergetic states. The container is filled with identical balls that ideally elastically collide with each other and with walls, similar to the molecules of the ideal gas. A number of balls are somehow marked; viz. they possess some property which makes them distinct from other balls, but which in no way alters their relevant interactional properties. At the starting point, the balls are evenly distributed over the entire volume of the container [Fig. 1(a)]. An invisible demon, which can control the sliding door that separates the chambers without affecting the system, decides to temporarily enable the passage of only marked balls from chamber B to chamber A. Collision processes will soon establish the condition [Fig. 1(b)] in which the balls in the chambers are distributed evenly in total number, except that in A, the number of marked balls is significantly higher than in B.

An external observer X, who does not know about the existence of the demon, concludes that the equilibrium of the system has been disturbed since the unusual concentration of marked balls in chamber A has reduced its entropy and that the total number of possible states in which each ball can be found is four: (A, marked), (A, unmarked), (B, marked), (B, unmarked). She will quickly notice that the mixing process is not random and deduce the rule that governs it. She will also observe that after the initial disturbance, the system will spontaneously tend to return to the equilibrium state, with entropy growing until the balls are evenly distributed over possible states. Note that all causal processes directly observable to X are purely physical in nature and comply with known physical laws. Everything that the demon did was to introduce a temporary selection rule in order to redistribute the probability of finding the balls in A and B, where the selection criterion was the possession of the property 'marked.' X will conclude that this selection rule led to an apparent correlation through which a series of successive random events resulted in a new, ordered state of the system. This correlation is a result of the probability redistribution caused by, first, doubling the statistical weight of the states A and B due to the existence of two new possible states of the ball, and second, the redistribution of the probability of microstates due to the tendency of the 'marked' balls to be in state A.

Observer Y, however, who is – for some reason – unable to see the marks on the balls, will perceive a system in which the balls are identical in all parameters [Fig. 1 (c)], and can be found in only two states: A and B. She will note that only known mechanical forces act in the system causing the balls to move chaotically so that the system is always in a state of dynamic equilibrium or maximum entropy.

If the demon is replaced by the action of the mind, balls by arbitrary identical subsystems within a broader conservative system and marks on the balls by some mental property unobservable to the outside viewer Y and perceivable only from the "first-person" perspective, i.e. by the mind, which is thus the only entity that can play the role of the observer X, we get a rather simplified but illustrative description of the proposed dualist mechanism of mental causation. The redistribution of the physical quantities in the system depends on the distribution of unobservable mental state variables determined by psychophysical laws, which means, on the selection criteria imposed by the mind – the criteria by which the individual subsystems are picked out by the mind, or 'marked', as well as the criteria by which these selected subsystems are allowed to pass through the boundary. The latter selection criteria are determined by the boundary condition set by the mind at the barrier. In our simple case, the 'marked' and 'unmarked' subsystems differ only numerically, in a classical experiment with Maxwell's demon by velocity, while in realistic cases they can be distinguished according to energy, momentum, charge, or some other physical property or their combination.

A few important conclusions can be drawn from this simple thought experiment. First, our suspicion that the mind can operate by violating the Second Law is confirmed. Second, the intentional nature of the mind's actions grounds a belief that there are nomological relations between physical and mental parameters of the system, which implies the existence of yet unknown psychophysical laws, not unlike those postulated by Chalmers (1996). Third, these laws, being manifested through anomalous correlations and redistribution of the physical properties in the system, can only be probabilistic in nature.

The subsystems represented by the balls do not necessarily have to be individual particles; they can be more complex systems, such as ion channels, synapses or entire neurons. The interactionist explanation must solve the problem of the identification of the mind-body nexus, i.e. the site where the causal interaction between mental and physical properties takes place. So far it has been sought for in the presynaptic membranes of the axons (Beck and Eccles [1992]), in microtubules – cylindrical protein lattices in the neuronal cytoskeleton (Penrose [1994]) and other places. The aim of the arguments presented here, however, is not to develop a complete model of mental causation, but only to demonstrate that the construction of a convincing and intelligible interactionist model is conceivable and realistic.

The role of the observer Y corresponds to the role of a researcher who, by using physical measuring instruments and his own senses, tries to directly perceive mental parameters and mental causation. To her perception only physical properties are accessible so that her description of events corresponds to the viewpoint of current physics: all events in the system are physically causal and their final outcome, the ordered state, seems purely coincidental. She will not even notice the violation of the Second Law, nor will she be able to explain the causality and intentionality of the events she has witnessed. According to her, the proceedings in the system are purely physical; they are in line with the causal closure of the physical. This description is incomplete because it is clearly impossible to give an account of mental causation by the means of current physics only. The mental causation, manifested by the action of mental forces operating in a classically conceived way, would lead to an anomalous acceleration of balls in the container, which would result in their heightened concentration in one of the chambers, accompanied by a change of the total energy and momentum in the system. The failure to detect such goings-on in the system clearly indicates that some other mechanism of causality is operational.

Obviously, physics is indifferent to the possibility of the existence of this type of causation. It is ‘blind’ to mental properties, but it does not *a priori* oppose them. If empirical research shows that significant properties of brains and neural systems of living creatures cannot be described without their introduction, physics will eventually incorporate them into its theoretical system. I believe that such research is possible and that the starting point should be a thorough analysis of the anomalous neural correlations, performed with the apparatus of contemporary physics and physiology.

5. Conclusion

Maxwell’s demon is a gift that keeps on giving. A century and a half ago, it helped us in clearing up the complex relationship between thermodynamics and statistical physics. During the next century and a half, it provoked an army of brilliant scientific minds into thinking about the ways of banishing its looming presence which apparently threatened the precious Second Law of thermodynamics, thus preventing the possibility of perpetuum mobile of the second kind. Whether this endeavor was successful is a controversial issue, but its byproducts are numerous works which enhanced our general knowledge. Nowadays, the demon seems to point both physicists and metaphysicians to a new direction, fraught with ontological challenges.

Physics does not deal with causal relations. It does not even contain causation in its vocabulary – the causation is a proper metaphysical notion. Nevertheless, no scientist would be worthy of that name if he or she would not be primarily concerned with the causes of natural occurrences. Therefore, the question of mental causation and its relationship with the physical causation is of interest to both philosophers and scientists. It pertains to one of the most important and intriguing questions ever asked: what is the nature of the mind-body relation? As this discussion demonstrated, Maxwell’s brainchild seems to be, quite surprisingly, an unavoidable element in the discussions of these deep ontological issues.

If my inferences were proven correct, an important link would be established between the domains of reality which, since Descartes, often seemed too far apart to causally interact: the domains of the physical and of the mental. There may be a way to develop a probabilistic theory of both physical and mental causation. The first step must be the verification of the presence of anomalous neural correlations, as a manifestation of the presence of mental causation. This task is within the means of physics and physiology. At any rate, this rare occasion, where science and philosophy join efforts in pursuing a high cause, is a sign of exciting times. And a little helping demon might just be their unsung hero.

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MAKSVELOV DEMON I INTERAKCIONIZAM

Maksvelov demon je zamišljeno biće, koje je pre jednog i po veka izmislio Džejms Klark Maksvel da bi ilustrovao statističku prirodu Drugog zakona termodinamike. On nam je pomogao u boljem razumevanju ne samo ovog zakona, nego i odnosa statističke fizike i termodinamike. Od druge decenije prošlog veka on izaziva poplavu radova naučnika koji pokušavaju da spasu Drugi zakon od pretnje demona i na taj način spreče mogućnost perpetuum mobile-a druge vrste. U novije vreme, pomaže nam da bolje razumemo mogućnost konstruisanja interakcionističkog modela mentalne uzročnosti, koja bi se manifestovala kroz narušenje Drugog zakona termodinamike od strane uma.

Ključne reči: *Drugi zakon termodinamike, statistička mehanika, Maksvelov demon, interakcionizam, mentalna uzročnost*