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Introduction

The final chapter of *Difference and Repetition* shares much in common with chapter two. There, we saw Deleuze arguing that representation tended to falsify our understanding of time by relating it to the structures of common sense. Deleuze instead presented an account of time that grounded (or rather, ungrounded) it in a field of intensive difference. Chapter five turns to the nature of space. Deleuze notes that difference *is* connected to intensity in the branch of science known as energetics, or thermodynamics. As we shall see, Deleuze's claim is that because thermodynamics sees the world in terms of systems that are already constituted (good sense and common sense), it is subject to the transcendental illusion that differences in energy or intensity tend to be cancelled out. This is what leads to Boltzmann's famous hypothesis that the end of the universe will be a form of 'heat death', where all of its energy is homogenously distributed, thus making any kind of order impossible. For this reason, in chapter five, Deleuze focuses on the role of intensity in constituting systems and the space that they occupy. Recognising this moment gives us a more positive account of intensity. In the process, Deleuze clarifies how the differential model of Ideas that we looked at in the last chapter can be related to the field of intensive difference that Deleuze introduced in opposition to Aristotelian metaphysics.

Thermodynamics and Transcendental Illusion (222-229/280-288)

Deleuze opens chapter five with a discussion of thermodynamics. As the name suggests, thermodynamics deals fundamentally with the properties of heat. As a modern science, it originated with Carnot's publication of his *Reflections on the Motive Power of Fire* in 1824. Carnot's aim in this paper was to explore the relationship between temperature and the efficiency of engines. The main result he discovered was that the efficiency of even an ideal frictionless engine was dependent on the difference between its hottest and coldest parts: the greater the difference, the greater the efficiency. Thermodynamics as a discipline emerged prior to the general acceptance of atomic theory, and as such makes few assumptions about the composition or specific mechanisms in operation within the systems it considers. This means that it can be applied to a variety of different types of systems, and as Deleuze suggests, its agnosticism as regards the actual processes of heat transfer mean that it is relatively easy to take its specific physical claims as providing 'local manifestations of a transcendental principle'. (DR 223/281) In this lecture, I want to explore Deleuze's engagement with thermodynamics by looking at three questions. First, what is the transcendental principle that thermodynamics embodies? Second, why does this transcendental principle reinforce rather than overturn good sense? And third, why does Deleuze consider this transcendental principle to be a transcendental illusion?

As you might know, thermodynamics rests on three laws. The first of these laws is effectively the law of conservation of energy. This states that the amount of energy within a system is conserved, although it can change forms. While this is an important principle, the transcendental principle of thermodynamics that Deleuze discusses rests on the second law of thermodynamics. This is, in Clausius' formulation, the claim that 'heat does not pass from a body at low temperature to one at high temperature without an accompanying change elsewhere.' (Atkins 2010: 42) Now, this statement rests on a central insight by Carnot that, when we look at a system, the work that the system is able to do is not dependent on the heat entering the system, but rather on the *difference* between the temperature entering the system and the temperature leaving the system. Thus, if we wished to improve the efficiency of, say a steam engine, we could do this either by increasing the temperature of the steam that powers it, or alternatively, we could reduce the temperature of the environment surrounding the generator (although only the first of these alternatives is in general really practical). The important implication of this is that what allows work do be done by a system is not intensity (temperature in this case), but rather difference in intensity (and in fact, Deleuze makes the stronger claim that 'intensity is difference' [DR 223/281]). Carnot's work shows that if the input and output energies of an engine were equal, the efficiency of the engine would drop to zero. Thus, difference is fundamentally implicated in 'everything which happens and everything which appears.' (DR 222/280) In line with Deleuze's distinction between the transcendental and the empirical, Deleuze draws from this the principle that 'every phenomenon flashes in a signal-sign system.' (DR 222/280) Just as the difference in the intensity of temperature gives rise to work, Deleuze's claim is that more generally, differences in intensity manifest themselves as qualities in the phenomenal world. Thus, Deleuze takes there to be an implicit transcendental principle at play in thermodynamics that it is difference that leads to work, and hence to the emergence of the kinds of diversity we find in the world around us. If this were the final result of thermodynamics, then clearly it would provide a model of physics commensurate with Deleuze's metaphysics. Deleuze claims, however, that thermodynamics betrays its own principle of difference through the introduction of entropy, and the concomitant equalisation of differences.

We can now turn to the second question, why does this transcendental principle tend to reinforce common sense? If we return to Carnot's engine, we can see that useful work cannot be done with total efficiency by the engine (except in the impossible situation of a difference between absolute zero and an infinite temperature). What happens to the heat that isn't converted into work by the engine? Well, this energy is introduced into the output reservoir as heat (just as a steam engine heats the environment as well as moving the train). Thus, in the process of doing work, the system reduces the difference between the two temperatures. It is possible to reverse this process within the system itself by doing work (a refrigerator, for instance, is able to reduce the temperature of objects placed within it), but this work itself will not be totally efficient. We can see this in the case of the refrigerator if we take into account its environment. In order to create a temperature differential, it requires a flow of energy from outside of it. So while the refrigerator allows heat to flow from bodies at low temperature to bodies at higher temperatures, this is only as a result of an interaction with its environment whereby energy is supplied to it by equalising a temperature differential elsewhere (the power station, for instance). Implicit in the second law of thermodynamics is therefore the claim that the amount of disorder, represented by heat that is unable to usefully perform work, will increase over time. This is commonly described by talking of an increase in the entropy of a system over time:

> When two isolated systems in separate but nearby regions of space, each in thermodynamic equilibrium in itself (but not necessarily in equilibrium with each other at first) are at some time allowed to interact, breaking the isolation that separates the two systems, allowing them to exchange matter or energy, they will eventually reach a mutual thermodynamic equilibrium. The sum of the entropies of the initial, isolated systems is less than or equal to the entropy of the final combination of exchanging systems. In the process of reaching a new thermodynamic equilibrium, total entropy has increased, or at least has not decreased.

The classic example The law can be illustrated by the example of a room containing two gases, for example, nitrogen and oxygen, each separated from the other by a central barrier. We can see such a system as presenting a high level of order, as each segment of the room contains just one kind of molecule. When the barrier between the two sections is removed, the free movement of molecules from one section to the other leads to a gradual mixing of the elements. Eventually, the system will reach a point of equilibrium, where the mixture of the molecules is relatively complete, meaning that the gas in the room has become homogenous. Now, in this case, the system now has less order than it had when the gases were separated from one another. In effect, we can say that the gas tends to find itself in a state whereby the molecules are relatively evenly distributed, because there are far more of these kinds of states than states where the gases are sharply separated from one another. Now, it would be possible to somehow separate the gases back out into the two original sections of the room, but this would involve us applying some kind of process, or in other words, it would involve us adding energy into the system from the outside. This is effectively what happens in the case of the refrigerator. In this case, a temperature differential is maintained in the system because the system exchanges heat with its environment (it is what's known as an open system). If we look at the universe as a whole as a system, we can see that in this case, there is no further environment that it can exchange energy with (it is a closed system). Now, given the first law of thermodynamics, which states that there is a fixed quantity of energy in the world, then over time, as various processes in the universe do work, more energy will be lost as heat as a result of inefficiency. Eventually, the differences in intensity that make work possible will themselves be equalised by this loss of heat, leading to what Boltzmann called the 'heat death' of the universe, as it becomes a homogeneous field of constant temperature. This is perhaps the most important result of thermodynamics. Physical processes on the atomic level are perfectly reversible. That is, if we work through the mathematical equations behind the collisions of two atoms, then, because momentum (or the total energy of the atoms) is conserved, then the mathematics of the collision is agnostic as to whether we run time backwards or forwards (just as – ignoring air resistance for a moment – if you throw a ball up into the air, it will return to earth at the same speed at which it was thrown). When we are dealing with large numbers of molecules, the entropy of a system has a tendency to increase, however. That means that even though time has no directionality on the atomic level, we can understand why on the macro-level, when we are dealing with large numbers of atoms, time appears to move in a definite direction (from the differentiated to the undifferentiated heat death).

Deleuze relates this result to the structures of good sense and common sense. As we saw, common sense refers to the indeterminate structures of the subject and the object. In other words, common sense simply asserts that it is the case that anything we encounter will have the structure of an object. Now we never actually encounter the kinds of indeterminate objects that common sense proposes, but rather a field of objects, each with diverse properties. It was good sense that related these various properties together into a hierarchy, such as the tree of Porphyry, affirming their ordered relation to the object as an instance of an object in general. Now, the question is, how do we relate common sense to good sense? Deleuze claims that it is the principles of thermodynamics that allow us to do this. If the properties of objects are defined by differences in intensity, then thermodynamics shows that over time, these differences, and hence the properties they sustain will be cancelled out. The heat death of the universe, with its model of total homogeneity, is the final affirmation of the true nature of the world as grounded indeterminate subjects and objects, despite the transient appearance of diversity that appears to signal otherwise.

‘[Good sense] ensures the distribution of that difference in such a manner that it tends to be cancelled in the object, and because it provides a rule according to which the different objects tend to equalise themselves and the different Selves tend to become uniform, good sense in turn points towards the instance of a common sense which provides it with both the form of a universal Self and that of an indeterminate object.’ (DR 226/285) Thus, organised systems tend to fall into disorder over time as the intensive differences that allow structure and useful work to take place give way to a disordered field lacking in any organising differences in intensity. Ultimately, the kinds of differences that complicate our understanding of common sense and require the introduction of good sense are shown to be inessential as the universe falls back into a field of objects with no differences in intensity, and hence with no properties. While thermodynamics therefore appears to affirm difference, in fact, difference is discovered to be inessential and transient, and therefore simply a moment on the journey of the universe towards indeterminate identity.

This brings us onto the final question. Why is this result of thermodynamics in the end a transcendental illusion? That is, why is it a necessary feature of our thinking, but one that nonetheless leads us into error. As Deleuze notes, the theory of thermodynamics is a partial truth, but it becomes a transcendental illusion when we ‘[attach] the feeling of the absolute to [this] partial [truth].’ (DR 226/284) This partial truth operates from the framework of ‘forms of energy which are already localised and distributed in extensity, or extensities already qualified by forms of energy.’ (DR 223/281) As such, it assumes the differences in intensity as already given as preformed. What is missing from the thermodynamic model is an account of the genesis of these intensive differences in the first place, and their localisation in particular regions of extensity (space). As Deleuze puts it, ‘perhaps good sense even presupposes madness in order to come after and correct what madness there is in any prior distribution.’ (DR 224/283) In other words, the theory of thermodynamics can explain the heat death of the universe, but it cannot explain the field of differences that we begin with which is to be cancelled. This moment of the emergence of difference remains outside of the thinking of common sense and good sense.

Stewart and Cohen (2000: 258) argue similarly in their study of complexity theory that the classical model of thermodynamics works well for the kinds of systems its inventors were interested in. These situations were where we have an individuated, isolated system that is brought into interaction with another system (the engine being brought into relation with its environment, or in Boltzmann’s classic example, the mixing of two gases). In these cases, the amount of disorder increases because the number of systems has reduced, just as ‘a children’s party with ten children is far more chaotic than two parties with five each.’ (Stewart and Cohen 2000: 258) If we move away from the mechanical models of the nineteenth century, we find that frequently systems are not just put into relation to their environment, but also are capable of isolating themselves from this environment. Life, for instance, is a process of individuation whereby new systems emerge, and with this emergence, decrease the amount of entropy present in the world: ‘The features that are of interest when studying steam engines, however, are not particularly appropriate to the study of life...For systems such as these, the thermodynamic model of independent subsystems whose interactions switch on and off is simply not relevant. The features of thermodynamics either don’t apply, or are so long-term that they don’t model anything interesting.’ (Stewart and Cohen 2000: 259) While thermodynamics provides an account of process affecting pre-constituted systems, qualities, and extensities, it does not account for the emergence of these systems, qualities, and extensities in the first place. We can note further that in the case of the mixing of two gases, or the engine, we are dealing with situations where systems are brought into relation with one another, but the two systems are brought into relation by an element outside of the systems themselves (the removal of the barrier separating them from each other). It is this moment of decreasing the number of systems that gives time its directionality.

Conclusion

That's all I wanted to say about the transcendental illusion of thermodynamics. As we can see, it essentially involves seeing the world in terms of constituted systems. Once we recognise that within the world, we do not simply have a reduction in the number of systems we encounter, but also the frequent constitution of new systems, we can see that thermodynamics gives us only what Deleuze calls a 'partial truth' about the nature of intensity and difference. Differences do tend to become cancelled, but this does not prevent the constitution of new differences of intensity within the world. In the next few weeks, we will look at Deleuze's account of how difference of intensity manifest themselves in the phenomenal world. Next week, we will begin to explore this account by looking at two different notions of depth at play in Merleau-Ponty's work in phenomenology. As we shall see, this phenomenological account tells us part of the story