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Relationship between Physics and Chemistry

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Abstract — Physics is the most fundamental and part of the sciences and physics has a profound effect on all scientific development. In fact, physics is the present-day equivalent of what used to be called natural philosophy, from which most of our modern sciences arose. In Different fields so many Students find themselves studying physics because of the basic role it plays in all phenomena. In this paper we will try to explain what the fundamental problems in the other sciences are, but of course it is impossible in so small a space really to deal with the complex, subtle, beautiful matters in these other fields. Lack of space also prevents our discussing the relation of physics to engineering, industry, society, and war, or even the most remarkable relationship between mathematics and physics. (Mathematics is not a science from our point of view, in the sense that it is not a natural science. The test of its validity is not experiment.) We must, incidentally, make it clear from the beginning that if a thing is not a science, it is not necessarily bad. For example, love is not a science. So, if something is said not to be a science, it does not mean that there is something wrong with it; it just means that it is not a science.

Keywords **-** Chemical descriptions Molecular chemistry Quantum mechanics Bohmian mechanics

I. INTRODUCTION

How are physics and chemistry related? The typical answer to this question in chemistry textbooks as well as much literature in philosophy and the sciences is reductionist, much in the spirit of Paul Dirac's famous quote: The underlying physical laws necessary for the mathematical theory of a large part of physics and the whole of chemistry are thus completely known, and the difficulty is only that the exact application of these laws lead to equations much too complicated to be soluble (Dirac 1929, p. 714). There are, of course, some powerful philosophical justifications for this kind of answer. For example, metrological dependence–where properties of wholes depend in some way on properties of their parts–looks to indicate that quantum physics supplies the "parts" for for the "wholes"–molecules–of chemistry. In other words, quantum physics provides the base from which the properties of chemical molecules arises. Another justification for this reductionist perspective comes from the completeness of physics (CoP). Here, we can distinguish two forms. In the epistemic form, CoPe, physics aims for a complete description of physical phenomena. Since descriptions of chemical phenomena crucially involve elements from physics, physics descriptions ought to yield chemistry descriptions (modulo derivational complications referred to by Dirac). In the ontological form, CoPo, physics involves fundamental laws of all matter. Since, chemical phenomena crucially involve elements from physics, the laws and properties of physics ought to yield chemical laws and properties (modulo derivational complications). The usual story for this reductionist relationship between chemistry and physics, runs roughly as follows (Hendry 1998): Chemistry should be a completely quantum mechanical affair as the first principles underlying chemistry are to be found in the domain of quantum mechanics. Therefore, in principle we can get chemistry from physics by some form of deduction, implication or derivation. For instance, in quantum chemistry, one first specifies the fundamental physical interactions (electromagnetic, strong- and weak-nuclear, etc.), then enumerates the relevant particles and their properties (nucleon, electron, charge, mass, etc.). Next, one lists the pairwise interactions among the particles. Finally, one writes down the kinetic and potential energy operators and adds them to get the system Hamiltonian (an expression for the total energy of the system). With the Hamiltonian in hand, one then proceeds to derive the properties and behaviors of the chemical system in question. But, as the usual story continues, this program is mathematically intractable. We can neither write the fundamental Hamiltonian down nor do we have the computational resources to carry the program through (Dirac's complications). No worries, though, as there are a number of approximation methods affording the construction of tractable, if inexact, Hamiltonians (e.g., associating electronic states with a "fixed-nucleus" Hamiltonian, or treating molecular vibrations in he small oscillation limit). The approximate equations derived from these procedures are then taken to stand in for the unobtainable first principles equations. This story has been called the "Proxydefense" by Robin

Hendry (1998). In the epistemic version of this story, the less fundamental theory is deducible from more fundamental theory, while in the ontological version, the less fundamental phenomena are deducible or derivable from the more fundamental phenomena plus the fundamental laws. In this essay, I want to demonstrate how molecular chemistry, in particular the feature of molecular structure, challenges this usual reductionist story. However, I will also point out how molecular structure challenges a quite popular formulation of emergence as well. I will end by sketching an alternative way of reformulating such notions as reduction and emergence, relating this alternative account to the feature of molecular structure and defending it against some objections.

II. Physics

Physics is the most fundamental and all-inclusive of the sciences, and has had a profound effect on all scientific development. In fact, physics is the present- day equivalent of what used to be called natural philosophy, from which most of our modern sciences arose. Students of many fields find themselves studying physics because of the basic role it plays in all phenomena. In this chapter we shall try to explain what the fundamental problems in the other sciences are, but of course it is impossible in so small a space really to deal with the complex, subtle, beautiful matters in these other fields. Lack of space also prevents our discussing the relation of physics to engineering, industry, society, and war, or even the most remarkable relationship between mathematics and physics. (Mathematics is not a science from our point of view, in the sense that it is not a natural science. The test of its validity is not experiment.) We must, incidentally, make it clear from the beginning that if a thing is not a science, it is not necessarily bad. For example, love is not a science. So, if something is said not to be a science, it does not mean that there is something wrong with it; it just means that it is not a science.

III. Chemistry

The science which is perhaps the most deeply affected by physics is chemistry. Historically, the early days of chemistry dealt almost entirely with what we now call inorganic chemistry, the chemistry of substances which are not associated with living things. Considerable analysis was required to discover the existence of the many elements and their relationships—how they make the various relatively simple compounds found in rocks, earth, etc. This early chemistry was very important for physics. The interaction between the two sciences was very great because the theory of atoms was substantiated to a large extent by experiments in chemistry. The theory of chemistry, i.e., of the reactions themselves, was summarized to a large extent in the periodic chart of Mendeleev, which brings out many strange relationships among the various elements, and it was the collection of rules as to which substance is combined with which, and how, that constituted inorganic chemistry. All these rules were ultimately explained in principle by quantum mechanics, so that theoretical chemistry is in fact physics. On the other hand, it must be emphasized that this explanation is in principle. We have already discussed the difference between knowing the rules of the game of chess, and being able to play. So it is that we may know the rules, but we cannot play very well. It turns out to be very difficult to predict precisely what will happen in a given chemical reaction; nevertheless, the deepest part of theoretical chemistry must end up in quantum mechanics. There is also a branch of physics and chemistry which was developed by both sciences together, and which is extremely important. This is the method of statistics applied in a situation in which there are mechanical laws, which is aptly called statistical mechanics. In any chemical situation a large number of atoms are involved, and we have seen that the atoms are all jiggling around in a very random and complicated way. If we could analyze each collision, and be able to follow in detail the motion of each molecule, we might hope to figure out what would happen, but the many numbers needed to keep track of all these molecules exceeds so enormously the capacity of any computer, and certainly the capacity of The mind, that it was important to develop a method for dealing with such complicated situations. Statistical mechanics, then is the science of the phenomena of heat, or thermodynamics. Inorganic chemistry is, as a science, now reduced essentially to what are called physical chemistry and quantum chemistry; physical chemistry to study the rates at which reactions occur and what is happening in detail (How do the molecules hit? Which pieces fly off first?, etc.),and quantum chemistry to help us understand what happens in terms of the physical laws. The other branch of chemistry is organic chemistry, the chemistry of the substances which are associated with living things. For a time it was believed that the substances which are associated with living things were so marvelous that they could not be made by hand, from inorganic materials. This is not at all true—they are just the same as the substances made in inorganic chemistry, but more complicated arrangements of atoms are involved. Organic chemistry obviously has a very close relationship to the biology which supplies its substances, and to industry, and furthermore, much physical chemistry and quantum mechanics can be applied to organic as well as to inorganic compounds. However, the main problems of organic chemistry are not in these aspects, but rather in the analysis and synthesis of the substances which are formed in biological systems, in living things This leads imperceptibly, in steps, toward biochemistry, and then into biology itself, or molecular biology.

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