Even today, all of our education, especially in the exact sciences, is saturated with the residues of representations that have been "superseded scientifically." In view of this situation, it seems appropriate to present a new picture of the world just as uncompromisingly as Giordano Bruno and Galileo did for science that was modern in their day.

Introduction

It would be a misunderstanding to think that this book aims to deny recognized results or overthrow important theories through its examination of *concept formation in physics*.

The objection could be made that from all the discussions that I hold with the reader in what follows there results not one new experiment, that the point in question is an "idle game with concepts" that are neither true nor false but are simply *irrelevant* according to the doctrine of *physical positivism* (see Pascual Jordan).

But this objection, too, would be a fundamental misunderstanding not only of what is presented here but also of the possibilities of human thought altogether. This is true because *physical positivism* justifies itself by the necessity of critically testing the simplest statements. However, it is then equally true that, on the one hand, too much might be thrown overboard by such testing while, on the other hand, not all the remnants of earlier natural-philosophic views will have been removed.

To rephrase this dilemma: The revolution of thinking in the twentieth century is not yet *radical* enough in many respects. At the same time, it restricts the view of new possibilities quite unnecessarily when, in its wake, the role of thinking in forming knowledge is confined too narrowly.

The Role of Thinking in Physical Research

With some justification, physical positivism puts forth the condition "that every scientific pronouncement has real content and meaning

only insofar as it expresses relationships and laws in the material of our experimental experience" (P. Jordan, p. 141).[16]

"Relations and Laws"

In context, the emphasis of Jordan's statement lies in its latter part: Only insofar as the relationships and laws relate to *the material of our empirical experience* do the pronouncements expressed by them contain real content and meaning—for physics! From this point of view, it remains uncontested that the relationships and laws of pure mathematics have content and meaning—for mathematics! Most definitely being contested, however, and with a certain brutality, is that the pronouncements of physics can discern something as regards the "true essence of things."

One form of this, according to Gustav Mie, is that we want to get to know nature only to dominate it. Werner Heisenberg, with a much more careful formulation, puts it this way: "The natural scientist therefore has to avoid the direct merger of the basic concepts on which he rests his science with the world of the senses." This situation follows from the fact that with the "explanation of sense-perceptible qualities of matter from the behavior of atoms," it becomes clear "that sense-perceptible qualities cannot be ascribed at all to the final building blocks of substances in a simple way" (Heisenberg, p. 98).[10] However we look at it, science always strives for *relationships* and *laws*.

Here, the schizophrenia of modern humanity clearly emerges: Science does not engage in physics for the sake of ultimate answers. Instead, researchers try to *broaden* and *deepen* relationships and laws at the present boundaries of science that are not sufficiently clear—perhaps to *change* these relationships through the responses of nature to suitably posed experimental questions—to understand what changes are necessary to produce a more encompassing theory. By carrying out research in this way, the physicist's thinking is like that of any human being when faced with an external reality that

initially appears as an enigma. They solve and *grasp* such a reality by penetrating it with their own thought. However, in theorizing about what they do, those physicists state something quite different—that their thinking is completely incapable of understanding the true nature of things. It allows them, they claim, only to gain starting points for their *formulas,* in more or less arbitrary pictures (the fashionable word is *models*) of whose limits of validity they are aware. These formulas then lead to results that can be translated back into measurable quantities.

Only a negligibly small part of the resulting measurements serves the control of nature in the narrow sense of the word—in technology, for instance. The overwhelming part of all measurements serves the confirmation or rejection of certain theoretical ideas, or at least the determination of constants in more or less secure theoretical systems. Measurements can also serve to estimate whether certain experiments, which seem reasonable in principle, can actually have results that offer hope of success. If one, therefore, takes the phrase "control of nature" in the sense offered by the research attitude of modern physicists themselves rather than by theorizing about it, then it becomes merely a self-consciously humble paraphrase of *knowledge!* Just that. Even if one, as Faust, wants to "envision all creative activity and seed," it is still nothing else than *mastery of nature through thinking.*

It is a common understatement that natural science strives for the *control* of nature rather than its *intellectual* mastery. It seems that science is somehow ashamed of what is going on in man while he is cognizing. This is a result of the supposed insight that thinking has no content that belongs to nature. It has only social communication value for describing actions (experiments) that have to be undertaken and for reporting their consequences (needle deflections, for example). I want to follow the consequences of a new description of the goal of knowledge in the next paragraphs.

To begin with, we can see that no problem arises for the materialist, but even materialists use *thinking* to articulate their views of

"matter" or to give it dialectical foundations. They also use thinking when trying to come to terms with the results of the experiments of twentieth-century physics, which very much contradict the naïve concept of matter. To them, thinking is a material process, but only when they speak *about it*. When doing research, they behave just like the researcher that they call "idealistic" or "subjectivistic." The idealist and the materialist both believe in the *results* of their thinking that provide them with a certain image of the process. Those results are taken seriously. A difference arises when, afterward, one of them denies the power of thinking to make valid statements about the being of things, while the other uncritically takes the results of thinking for the existential basis of things. The first, paradoxically, is called the "idealist physicist"; the latter ascribes to thinking, believed to be a material process, the ability to take hold of matter. By that, the materialist's matter is something completely intangible. Its existence is merely the permanent basis for all physical changes. It is postulated.

The Worldview: Does It Belong in a Discussion on Thinking in Physics?

This book has to contain research about the real form of certain physical concepts, whether in the usual theoretical fields or within more methodically conscious and therefore, in a certain sense, more legitimate proceedings. And it has to contain a chapter in which the author resolutely makes the attempt, with the concepts that *he* has won so far, to create a view of the world.

I have asked myself the question of whether such a chapter should be at the beginning or at the end. Didactic reasons speak for the second placement, for then conceptual constructions are analyzed and purified before they are used. However, the other procedure—to expound upon the physics of matter and particles along with the description of a *world picture*—reflects my intention to avoid sacrificing life for the appearance of something systematic. In this way,

the general ideas take form even as the individual expositions are being formulated.

One reason to begin with the world picture may be added here. Physics, ever since the time of Galileo, has been working on the formation of a world picture. The physicists themselves only became conscious of this late within their factual work; this happened when they saw themselves in their own specialty facing obstacles and difficulties of understanding that were nothing less than the results of their own earlier (specialized) views that had been vulgarized into the popular worldview made absolute. Even today, all of our education, especially in the exact sciences, is saturated with the residues of representations that have been "superseded scientifically." In view of this situation, it seems appropriate to present a new picture of the world just as uncompromisingly as Giordano Bruno and Galileo did for science that was modern in their day.

I see one way to prevent the misapprehension that the scientific philosophizing that I am undertaking here might follow a fixed track: Formulate as clearly as possible the new kinds of consequences to which I see myself led by logic, doing so with honesty and with the courage of my convictions. This will at least dispel the accusation that I am striving to make a worldview *scientifically* acceptable that has actually been preordained by anthroposophy or that I am at carrying the contents of this "teaching" dogmatically into scientific thought.

Only in the course of this investigation may we hope to uncover the true function of thinking in physics. In any case, in even the simplest parts of physical science many conceptual distinctions lie hidden, whether we speak of phenomena *or* effects. *Who would deny that the rainbow is a single thing rather than merely the play of refraction and dispersion summed over countless drops?*