

PHILOSOPHIA SCIENTIÆ

ROBERT S. COHEN

Mach and Einstein. A posthumous dialogue

Philosophia Scientiæ, tome 3, n° 2 (1998-1999), p. 167-182

http://www.numdam.org/item?id=PHSC_1998-1999__3_2_167_0

© Éditions Kimé, 1998-1999, tous droits réservés.

L'accès aux archives de la revue « *Philosophia Scientiæ* » (<http://poincare.univ-nancy2.fr/PhilosophiaScientiae/>) implique l'accord avec les conditions générales d'utilisation (<http://www.numdam.org/conditions>). Toute utilisation commerciale ou impression systématique est constitutive d'une infraction pénale. Toute copie ou impression de ce fichier doit contenir la présente mention de copyright.

NUMDAM

Article numérisé dans le cadre du programme
Numérisation de documents anciens mathématiques

<http://www.numdam.org/>

Mach and Einstein. A posthumous dialogue

Robert S. Cohen

Boston University

Einstein : Respected Mach, where are we ? I have just arrived, just now. And you have been here for a few cosmic moments longer.¹

Mach : First let me welcome you to heaven. Perhaps we will speak with others. Tell me with whom you prefer to speak. From my point of view, I prefer Anaximander, our earliest scientific ancestor. Yes, Anaximander, but you may prefer that mathematical ontologist, Plato. But as to your question as to where we are, we are in heaven.

Einstein : So, we will need to interpret, to understand, what this strange word *heaven* signifies. But anyway, I see at once that we share some sensations. We are after all talking, we communicate our individuated appearances of heavenly sensations. Do we continue to be our old selves, are we still atomic individuals, are we still egos ? Oh, oh, oh, are there spooky actions at a distance here in heaven ? "I admit of course that there is a considerable amount of validity in the contemporary statistical approach which you were the first, Max Born, to recognize clearly and necessarily, given the framework of the existing formalism. But I cannot seriously believe in it, because the theory cannot be reconciled with the idea that physics should represent a reality in time and space which is free from spooky actions at a distance"². (Now as we all know these spooky actions at a distance by what has been done here in France by Alain Aspect and others).

Mach : All right, you do not like ghosts in heaven, but wait, please be cautious, be careful when you mention psychical or egocentric atomic individuals. You must recall my discomfort about the imaginary ideas of physical events, and also about psychical events. However useful such fictions may be, different fictions in different historical and scientific circumstances play different roles in that evolutionary history, not only of science, but of mankind. So go ahead, if you wish.

Einstein : Oh, I do recall all that. And I regret such carelessness. On my part especially, so soon after my arrival. But may I ask whether we have here any opportunity to meet the Lord, to learn more of the ways of that Old One who was always believed to have designed our world of life, experience down there.³ Perhaps He would let us see up there whether the world's

1 This is the transcription of the spoken dialogue. I thank Claire Hill for her help in completing my transcription and revising my English. My friend Shlomo Ben Abraham, Ben-Gurion University, was also helpful in discussing some of the physical notions involved (note by Jan Sebestik).

2 A letter from Einstein to Born.

3 Old one is the English translation of the German *der Alte*.

conjectured and imagined facts or fictitious entities are rationally complete or fundamentally chancy entities, whether they were right ? What is the case below in the universe ? Was it necessary, was it by chance, or in any case, are we with God still *in* the universe ?

Mach : How should I know ? I have no experience of that beyond those I had before being here. Except for great relaxation, a feeling of cosmic acceptance, I am at ease, with no personal troubles.

Einstein : That's heaven all right. That great acceptance means no struggle. I suppose, I suppose, we have somehow overcome individual strivings in coming here. That was always my own goal in science, in any case. Was it not yours ? I mean to transcend the private life, whether joys or pains, or sorrows, to think through to a partial understanding of the reasons the world works as it does.

Mach : Yes, you could word it that way, but your scientific reasons have logical certainty and deductive certainty filled in, and my goal was always less a matter of reasoning and world events, just only reason in the way of exploring and analyzing. My certainty was, I thought, only to be identified in the appearances of what I find within sense experiences.

Einstein : Whose sense experiences ? Did we not each have our own ? Was solipsism not inevitable in your view, or at least some Pyrrhonian or Humean skepticism ? Surely, such an epistemic danger was in your view.

Mach : Oh yes, a danger. But perhaps here, I was unclear about our clarity. I was uncertain about certainty. By this I meant that our sensations, well to me and you too, are our ultimate testing situation for our ideas. They, the sensations themselves fell into two sorts : those coming from without, external sensations to be explored by external means, as the question what is behind the external sensations ; and those arising from within, to be explored by intellectual means, as what is within, by introspection. Another kind of observation. So, the physical world of sensations, you might say, and the psychological world of sensations is what we have. But they are not different other than in their way in appearing to us. We *had* to allow for introspection as one way of observing, as well as the external observations.

Einstein : Sounds like Spinoza's two modes of being, but just in another language. Thus, of course, your own very *useful* character, could not say that much about Spinoza.

Mach : I suppose Spinoza – although I still must say I am no philosopher – and he was – and he is here, in any case. For me thus, the distinction bet-

ween the mental and the physical was only a matter of two ways of apprehension. Two methods, not at all two fundamental ontological realities.

Einstein : I wonder whether Spinoza might agree with that. I'd rather think he would.

Mach : As I say I do not claim the title of a philosopher. I want only to take in physics the standpoint which does not have to be abandoned immediately when we look over into the theory of another science. For all the sciences ultimately form a whole.

Einstein : Have you all that ?

Mach : Let me go on. Where I am standing, I am perhaps not the first to stand, and furthermore, I do not want to bring forward my explanation as an extraordinary achievement, not at all. I think rather that the same line would be taken by anyone who would try to survey the field of science which is not too narrow. The basis of all my investigations into the logical foundations of physics, as well as into the physiology of perceptions, has always had one basis and the same opinion, namely that all metaphysical propositions must be eliminated.

Einstein : Why ?

Mach : Because they are idle. They disturb the economical ideal of science. The tendency of my books was always just elucidatory, just an antimetaphysical one. And then I want to say further, if one wants to describe physics as the science of matter, and biology as the science of life, and psychology as the science of mind, sociology as the science of the collective mind, metaphysical concepts or words such as matter, life, soul, collective soul are always being introduced by the specialists for the obvious reason that matter and soul for example are probably not reducible to the same terms, as one another. It's easy to prove that.

Einstein : Well, that may be so ... what you say. For me, metaphysics and ontology just means reality, what is. And your two ways should work only because there are two realities, or two aspects of reality. Why trouble with the words ? What else would explain their success, these two words, introspection and external observation, if there are not two aspects or, in Spinoza's words, modes of reality ?

Mach : You are speculating again. And for you it's all right to do so, but not for me. I don't feel any need to do that. Or rather, I *sense* no distinction. I don't sense it. I need sensations to justify such a statement. We had only just a flock of sensations when we were down there.

Einstein : Down there ? That's an interesting metaphor. A special metaphor. And you use flocks, atemporally. What's going on ?

Mach : Well, like others, even like your young friend Russell in one of his many stages, I searched for a neutral word to cover all this, metaphysical and mental, to identify the two sorts, and I chose the word *element*. Ultimately, one science then which unifies all the historically understandable separate specialized sciences, with their separate specialized words, their own languages. We hope for unified scientific language, I and my friends.

Einstein : And thereby you want the unified science ? Unified single science and for our own epoch then, you wanted a unity of science movement to try to achieve this program, a movement among scientific workers, not philosophers, even among philosophical analysts of the sciences. That I understood. But how much more than that ?

Mach : Well, there is much more to say. We have to learn through history, just how scientific concepts and systems developed, how they were hindered by previous sciences and theologies, how practical life made its own demands on the sciences, how the very core of knowledge in science turns out, at least in my lifespan in the wonderful XIXth century period of enlightenment, to be knowledge only of relations among sensations. That was the core : relations, functions. What do you say of this viewpoint ? Does it provide full room for your own efforts – to use a non-visual metaphor – your program ? Did you speak out about me before you came over ? I think you did, didn't you ?

Einstein : Well yes. Of course, I spoke out about you, but let me speak a bit more. But let's see how we agree and how we differ. In one point, dear Mach, I wrote that the definition of simultaneity in the special theory of relativity is based on yours, on Mach's requirement that every statement in physics has to state relations between observable quantities. There is no doubt in Mach's requirement that positivistic requirement, if you want, was of great heuristic value.

Mach : I cannot share the view of Newton that one can distinguish between absolute and relative rotation. See, Einstein, I was before you. Now I cannot share this view. For me only relative motions exist and I can see in this regard no distinction between rotation and translation. Indeed, classical mechanics and the special theory of relativity has not suffered from the epistemological shortcoming of being the preferred position of uniform translation over all other types of relative motion. And that was

probably emphasized by me for the first time. Nevertheless, I also wrote, you remember, that I must assuredly disclaim to be a forerunner of Einstein's relativity, as I withhold from atomistic beliefs.

Einstein : Yes, you did write that, but you were very old then, you were almost on your way here. There can hardly be any doubt that this reaction of yours was a consequence of a capacity to absorb ideas, diminished by age. The whole direction of thinking of the theory of relativity is in concordance with yours. I really think that it is justifiable to consider you as a precursor of the *general* theory of relativity, after what you said about the shortcoming. Indeed, Mach's system, I wrote, consists of the study of relations which exist between experimental data. According to Mach, science is the totality of these relations. Now I said that the bad turn of view, dear Mach, in effect, that you made then would just be a catalogue and not an explanatory system. You were very good in mechanics, but you were wretched as a philosopher.

Mach : Well, you heard what I said, I don't want to be a philosopher. Remember my principle ?

Einstein : Of course.

Mach : When we say that a body preserves unchanged the direction and velocity in space, our assertion is nothing more or less than an abbreviated reference to the entire universe. What would become of the law of inertia, I wrote long before 1905, if the whole of the heavens began to move and the stars went in confusion ? How would we apply the law of inertia then ? How would we express it then, in the case of a shattering of the universe ? Would we learn that all bodies, each with its own share, are of importance in the law of inertia ?

Einstein : Oh, you are brilliant. I said you were good in mechanics. But would you then explain how it would be shared ? That's what relativity explains. We have plausibility to the conjecture that the total inertia of a mass point is an *effect*, not a property, an effect due to the presence of all other masses due to a sort of interaction with matter. That's just your point of view, isn't it ?

Mach : Well, what a chance for the spooky interaction ?

Einstein : I still think, to summarize this, that your view of inertia was the hypothesis of the relativity of inertia. And I have never stopped praising you for that.

Mach : Well, so the critique of history leads to advances as I hoped when I criticized Newton, and Newton is that way, too.

Einstein : This critique has a danger, nevertheless. Can we judge the philosophy, or a methodological requirement for science, which is what I mean by a philosophy for science – and you mean that too – can we judge it by its fruits, by its effective influence upon scientists ? There is someone else who speaks to this point. And you remember him.

Mach : You probably mean that young man Planck.

Einstein : Yes. Planck remarks that whoever rejects space, dear Mach, whoever rejects space and the reality of atoms and electrons, or the electromagnetic nature of light waves, or the reality of identification, the identity of heat and motion, can never be found guilty of a logical or empirical contradiction. If he rejects that – but he will find it difficult from his standpoint ever to advance physical knowledge. I follow him up. The prejudices of these scientists, I wrote, against the atomic theory can undoubtedly be attributed to positivistic philosophical views. This is an interesting example of how the philosophical prejudices hinder a correct interpretation of facts. Even scientists with bold thinking and subtle intuition hinder this.

Mach : I don't think that's right. In the investigation of nature, one must be tough-minded. We have to deal only with knowledge of the connections of appearances with one another. Relations. What is, in respect to ourselves behind the appearances, exists only in our understanding and has for us only value of a *memoria technica*. A formula whose form, because it's arbitrary and irrelevant, varies, varies easily with the standpoint of our culture. Whatever works for us, works for us. It says nothing about what stands behind. But let us suppose for a moment that all physical events can be reduced to special motions of material particles, namely atoms. What do we do with that special supposition. Thereby we suppose that things which can never be seen, never be touched, and only exist in imagination and understanding *can have*, we suppose this, can have the properties and relations only of that which exists, only among things, which can be touched – so far as we know. We impose upon the creation of our thought the very limitations of the visible and the tangible. In a complete theory, for all details of the phenomena, details of the hypothesis or theory must correspond. And all rules for these hypothetical things must also be directly transferable to the phenomena. But then all of your atoms are merely a valueless image because they add nothing to that correspondence.

Einstein : You sound like a preacher trying to make a picture model of reality. That the things have gears.

Mach : Gears ? I worked with that when I worked as a young man with a mill. It was wonderful. To see how the water flowed and the mill wheel turned and the gears turned, and the corn was ground. Yes, that's touching and seeing.

Einstein : Well, that's true for some models, but there are other models.

Mach : So we need to engage in model thinking, you say.

Einstein : Yes, when do we tell whether they are validated or not.

Mach : In experience.

Einstein : How strong your methodological restrictions are. Honestly, you seem almost opposed to what is actually the meaning of a theory. You depend wholly upon experiment and observation. You wrote somewhere, something that you found in Goethe : "Hypotheses are the scaffolds which are erected upon a building and removed when the building is completed. They are indispensable to the worker, but he must not mistake the scaffolding for the building. The constancy of phenomena alone is important. What we think about them, our scaffolding, is quite immaterial."⁴ You seem to me to be just like that wonderful Sherlock Holmes.

Mach : Sherlock Holmes ?

Einstein : Yes, another fictional entity with reality.

Mach : Another fictional entities with reality ?

Einstein : Wait, wait what did this fictional reality say. As follows in the novel *A scandal in Bohemia*. "I have no data yet", says Sherlock Holmes "it is a capital mistake to theorize before one has data. Insensibly one begins to twist back, to sow theories, instead of theories to sow facts".

Mach : Well, I never read English mystery stories, but he has it right.

Einstein : But the theory is the intellectual scaffold, Wittgenstein's ladder is to be thrown away. Sure, it's true about theories, but how much depends, how much really depends upon a rich luxurious theory, not an austere economy of thought, not sensations as *minima*. Never mind the sensations. The observations are minimal. And the theory which generates them

can be rich and luxurious again. One must still remember the truth of your predecessor Auguste Comte.

Mach : What do you mean by the truth of Auguste Comte ?

Einstein : What I mean by this is what he wrote himself about the theory-ladenness by observations.

Mach : Comte said that ?

Einstein : As follows : “As on the one hand, every positive theory has to be based on observations, it is on the other hand also true that our mind requires a theory in order to make observations.” This is 1829, Mr Mach, 1829, *Cours de philosophie positive*. “If in contemplating phenomena we did not link them immediately to the principles, it would not only be impossible to combine the isolated observations and draw any useful conclusions, we would not even be able to remember them. And for the most part the facts would not even be noticed by our eyes. Hence, squeezed between the necessity of observing in order to form real theories, and a no less urgent necessity of reproducing some theories in order to make coherent to bservations, human minds had not been able to break this circle if a natural way out had not been opened up in history, by the spontaneous growth of theological conceptions.”

Well, it becomes clear that we depend on theories before facts. And many people have said that since you and me, Comte and Mach, and I count you with him, could not hold the opinion that the laws of nature might be raised from experience. The feeling was so strong that Comte accepted even theological principles as a starting point. Why ? In order to get science going. To find up where we are. Perhaps we needed a tablet to write on.

Mach : Well, you have to remember what Poincaré said at one point. At first glance, it appears to us that a theory lasts only a day and ruins heap up upon ruins. If we examine the matter more closely, however, we find that what decays in those theories which claim to teach us something more is just those theories decaying, but there is something in them which endures. If one of them has revealed to us a true relation, this relation has been acquired for all time. We shall try it again under a new form in other theories which will reign successively in its place.

Einstein : That’s probably exactly right for both of us. We both agree that theories change and yet those relations that Newton described and attempted to explain are still explained, and the relations stand.

Mach : Let me repeat. If with the help of the atomic hypothesis a theory – if ever there were one – one could actually establish a connection between several observable properties without which it would remain isolated, then I should say that this theoretical hypothesis was an economical one. Because with this aid, the relations between various observations could be derived from a single assumption. I wouldn't have any objections if the mess was in computations which were difficult and complicated.

Einstein : Well, that's fine. Again, we agree. Just remember that by the words *simple and economic*, what you mean then is not psychological economy, not beauty, nothing other than *logical* economy. The observable properties should be derived from as few assumptions as possible, even if those assumptions might appear arbitrary, dear Mach, and the computational results might be difficult. So there is no longer any conflict between your standpoint and my standpoint as to the criteria to be filled by a physical theory.

Mach : It does not seem as though we do agree.

Einstein : On theory, surely, we must listen to Dirac. Beauty is more important than simplicity, more important than empirical fits. Listen to Dirac. I repeat. Your influence on my relativity theory, your acceptance that there may be a great gap, and not a close gap, between a theory and a testing experience, means we are much closer.

Mach : Oh, you know, dear Einstein, the role of a theory is to condense our knowledge, our observations. We called that a *formula* before. Then remember : if it were a case that our minds have all the time before it, and were vast enough to know all the facts before, there would be no need for a theory.⁵ Still, doesn't simplicity have to return ? We must choose between theories, and we choose only those that are more beautiful ? Remember, your friend Dirac's point was that a theory need not be rejected or disconfirmed by an observation. It was not against simplicity, to say that beauty can override the temporary rejection of experience.

Einstein : Well, that sounds right, but it also sounds phenomenalist, and phenomenism is not enough.

Mach : Sensations have another quality that you have not emphasized enough.

5 Someone else in the XIXth century remarked something of this sort : "All science would be superfluous if the manifest form and the detailed essence of things directly coincided and were directly always known." K. Marx, *Capital*, III.

Sensations are always *dependent* upon other sensations, however difficult this may be to elucidate.

Einstein : I don't think it *can* be elucidated. Why must they be dependent ? Why could not they be for all we know from time to time independent ?

Mach : In what sense ? Some sensations or some clusters dependent within the cluster might be independent of other characters.

Einstein : This is all an empirical matter of science. Anyway, what about perceptual space, if you are going to be so phenomenalist about science ? You seem to demand reality, the reality of your sensation-space, to be *Euclidean*. I am no psychologist, nor physiologist, but I do seem to recall that Helmholtz and Husserl and the later phenomenologists, Merleau-Ponty, that very young man the Jesuit Patrick Healy, they have all shown that a non-euclidean geometry is the geometry of the perceived space. The space which is actually seen is hyperbolic or something like that.

Mach : Well, that is a question of empirical science.

Einstein : Well, you may say that. Let me recall to you what the saintly American, the great saintly American philosopher Charles Saunders Peirce had said about you. "Mach belongs to that school of soi-disant experiential philosophers whose aim it is to emancipate themselves from all metaphysics and go straight to the facts." That's what he says. "This attempt would be highly laudable", says Peirce, "were it possible to carry it out. But experience shows that the experientialists are just as metaphysical as any other philosophers, with this difference, however, that their preconceived ideas, not being recognized by them as such, as preconceived, are much more insidious and much more apt to fly in the face of all facts of observation."

Mach : Metaphysics for me ? Never. Transcendentalism is impossible. Philosophy ? Well, maybe, after all. A whole host of philosophers, positivists, critical empiricists, adherents of the philosophy of immanence and certain isolated scientists even have all, even without any knowledge of one another's work, entered upon a path which, in spite of all the individual differences, converge towards one point, and the point of convergence is to reject metaphysics, and to adopt a critical positivism and empiricism. So I was on the threshold of philosophy by pursuing physics and physiology, well, trying to critically clarify these scientific puzzles that I have found inside physics.

Einstein : You leave me without roots here. The connections to experience are not at all clear. The distance from theory to experience is not clarified. You say one needs some kind of a faith in science. I said that. What about religion in science ? What about religion in general ?

Mach : Well, if you interpret it and tell me what it must mean and how I can validate it. Faith ?

Einstein : Yes, the faith that the world is rational.

Mach : That's not clear. You mean rational in the way theories are constructed ? Then you construct them that way.

Einstein : No, I cannot prove, and I can hardly even offer a theory about what it would be like to show that the world is understandable. In fact, as you heard me say on earth, I say it here, in front of the Old One himself. It's a wonder that the world is understandable.

Mach : Wonder ! That's a synonym for miracle.

Einstein : Well, it's a *necessary* wonder. The Old One himself could not make $4+3$ other than 7. I want to know how he was constrained.

Mach : By what ?

Einstein : By necessity, which is not defined arbitrarily by us.

Mach : It seems to me that this faith is something you can have and be happy with. I don't have it.

Einstein : What kind of faith do you have ? What kind of philosophy of life do you have, or did you have ?

Mach : Well, we have an incomplete knowledge of the world. It will always be incomplete.

Einstein : Yes, of course ; The question is how to live with it.

Mach : You live with it like a miracle, which you call, something as a wonder.

Einstein : What do you do ?

Mach : The highest philosophy of the scientific investigator is to bear an incomplete conception of the world, and prefer it to any apparently complete, but inadequate conception.

Einstein : I see. And the key word there is to *live* with incompleteness, and not pray, and not go for someone else to bring it to you.

Mach : Yes, to bear, to live with an incomplete conception.

Einstein : Let me try another test. What is the source of these ideas which give us this incomplete conception ?

Mach : That's a scientific question. I investigated it. I investigated it by looking at the history of scientific ideas, at the history of technological ideas, and by children. If we look at the children, and we look at a child without a race, if we become darwinians about the race, and child psychologists, then we see that they go together.

Einstein : Time is running out. Psychology is different from physics then. You are using Darwin and biology and evolutionary ideas. I am afraid that this is beyond what we can deal with now. Well, in the end we cannot commit ourselves really to any particular positivistic or realistic philosophical outlook. I think we have some things in common and other things where we radically disagree with each other. You worked on theory of knowledge, you were a scientist about knowledge. I am just a scientist, but I have to be clear. I realize that epistemology and science are related. They do depend on one another. Epistemology without science is an empty scheme. Science without epistemology, insofar as you can think at all scientifically, without at least an implicit epistemology, would be primitive and outmoded.

Mach : Indeed, that would not be science.

Einstein : However, no sooner has the epistemologist who seeks a clear system of knowledge, forced his way through such a system, then the epistemologist is inclined to interpret the content of science in the sense of his system, and to reject whatever does not fit into his system. That's what you were doing, and did, dear Mach. The scientist, however, and this is you when you were a scientist, cannot afford to carry his striving for epistemological system that far. The scientist accepts gratefully the epistemological conceptual analysis. All power to you. How great you were in conceptually analyzing Newton. But back to my remarks about systems. The external conditions of science which are set for him exactly by the facts of experience do not permit him to let himself to be too restrictive in the construction of his conceptual world by adhering to an epistemological system. I include yours among the systems so that you do not understand in your system what we have done in science. We have had transcendent theories and you were trying to eliminate them, to restrict them. So the scientist must appear to you, to any systematic epistemologist, as a kind of unscrupulous opportunist. Really a gangster. The scientist is a realist insofar as he is trying to describe the world which is independent of the acts of perception. And we will come to that in your view, too. He is to be an idealist insofar

as he looks upon concepts and theories as free inventions of the human spirit. And what does that mean ? It means being not logically derivable from modest empirically given, but inspired facts. And how ? We don't know. As a positivist, he considers his concepts and theories to be justified, only to the extent to which they furnish the logical representation of relations among the sensory experiences. And you are right in this respect. And the scientist may even appear to be a Platonist or even a Pythagorean, insofar as he considers the viewpoint of logical simplicity as an indispensable and effective tool. And indeed, Mach, I believe that the magic of mathematics is a way of getting intuitive insights into what may be reality. Why not ? Why not take that as the answer ? Multiple philosophical outlooks.

Mach : It would be so good, if you only could show that. Indeed.

Einstein : What of the human spirit ? Where does that appear in your neutral elements ? Your neutral elements, remember, unlike my faith in there being rationality in the universe to be explored tentatively. Your neutral elements seem to have no room for a *person* who has those elements. No room for ego, no room for individual ego, no person, no philosophy of personalism.

Mach : Now wait. You are going too far. I mean I said that our science is incomplete. I said that we have a biological evolutionary function for thinking.

Einstein : Thinking about what ? Thinking about the sensations and their relations. Who does this thinking ?

Mach : Thinking takes place. You must not have a metaphysical notion of an unobservable, non-sensationistic entity or being, ego or the mind doing the thinking. There is thinking. The elements have no theory of the mind.

Einstein : Nevertheless, I take it that you will agree with that great psychoanalyst Sandor Ferenczi. It seems to me you must agree with this : "Sense organs separate the world into elements". Your very word ! And Ferenczi goes on : "The mind restores it" (the world).

Mach : Again ? I did not know him. Sense organs separate the world into elements, the mind restores it. Aha, if we, positivists, could interpret the mind, there is a research program : the relationship among the sensations, how do the elements cohere.

Einstein : Come on, be careful now. That requires that there be something that you would recognize as, and forgive me, dear Mach, unsensed sensations, a mental realm not open to introspection, just as we say, we theoretical physicists, that there is a physical realm not open to direct observation of the

external sort. Theoretically, hypothetically an unconscious mental realm of unsensations. So, similar to the external world, open to creative imagination, both the introspective internal and the hypothetical external realms must be warranted by testing, but only warranted ?

Mach : I have only one defense, now. But a defense that I believed when I said it in 1883. See what you will, do what you will, with these words of mine. Ideas are not all of life. They are only momentary, designed to illuminate the patterns of the will. Indeed, the transformation of ideas representing sensations appears to us as a part of the general evolution of life. The transformation is part of life's adaptation to a constantly widening sphere of action. The arm of man ?

Einstein : The arm on man ?

Mach : It's only a metaphor. Yet the arm of man reaches far beyond the immediate. What an immense portion of the life of other people is reflected in ourselves. Their joys, their affections, their happiness, their miseries.

Einstein : How do we know, how do we know about other people's joys ?

Mach : By analogy to our own. I am not a solipsist. There is no need to be one. But listen to my last words on this : "How great and comprehensive does oneself become in this conception, but how insignificant the person".⁶

Einstein : I like that. The egoistical system spoke of optimism and pessimism.

Mach : Perish the thought ! With the narrow standard of the importance of the intellectual life we feel that the real perils of life lie in the ever changing contents of the consciousness. And in a person's being is merely an indifferent symbolical thread on which these sensations are strung, I no more draw an essential distinction between my sensations and the sensations of another person. The same elements cohere at a number of points.

Einstein : Cohere objectively. Cohere independently.

Mach : Cohere. The same elements cohere at a number of points of combination which are the self. – I had another follower just as important and just as careful about the beauty of his physics as was your Dirac.

Einstein : Oh, you mean Schrödinger.

Mach : Yes. I have heard of him that he wrote share thoughts, really, our thoughts in common. They are not similar thoughts. They are the same thoughts. They are identical. Indeed, the external world and consciousness are one and the same insofar as both are constituted by the same primitive

elements. But we are then hardly ever using a different formula when we express the essential community of these elements in all individuals by saying that there is only one external world and that there is only one consciousness, the lesson of Schrödinger. So there is a kind of serene ambivalence here.

Einstein : Are we all one now ? Or simply not yet when we got to heaven ?

The science of science has a philosophy to it after all, dear Mach. Science brings liberation to the world of action, you have said this repeatedly. Science also brings apparently salvation of a sort to the individual. Can this instrumentalist theory of liberation and this transcendent conception of salvation go together ?

Mach : It's all we have.