Michigan Philosophy News

for friends, alumni, and alumnae of the Department of Philosophy, The University of Michigan, Ann Arbor

Fall, 1993

Dear Friends of the Department:

Recent months will be remembered as a remarkable recruitment season, with Edwin Curley, Ruth Millikan, and Ian Rumfitt accepting positions in the Department during this period. Rumfitt's appointment is as assistant professor; Curley and Millikan, who are senior scholars of the first rank in their respective fields, join us as professors. We would have been fortunate to make any one of these appointments. Brief biographical sketches speak for themselves.

Professor Curley is an historian of seventeenth century European philosophy. He has written two books on Spinoza, and has published the first volume of his edition of Spinoza's *Collected Works.* He also has a book on Descartes, and has written widely on metaphysical and epistemological topics in Leibniz and Locke. His more recent work focuses on the moral and political philosophy of Hobbes. His contemporary interests include the philosophy of law and of film. He has been President of the Central Division of the American Philosophical Association, and is a member of the American Academy of Arts and Sciences. He comes to Michigan from the University of Illinois at Chicago.

Professor Millikan will join the Department (half-time) beginning the 1994-95 academic year. She works from a naturalist, Darwinian perspective in the philosophy of psychology, philosophy of biology, philosophy of language, ontology, and epistemology. She has two books: *Language, Thought, and Other Biological Categories* and *White Queen Psychology and Other Essays for Alice.* She has been a Visiting Fellow at Wolfson College, Oxford, and a Fellow at the Center for Advanced Study in the Behavioral Sciences. She presented the Gareth Evans Memorial Lecture at Oxford in 1991, and has been President of the Society for Philosophy and Psychology. She is currently Professor at the University of Connecticut at Storrs.

Professor Rumfitt specializes in the philosophy of language, philosophical logic, and issues at the intersection of philosophy and linguistics. He holds a B.A. and D.Phil. from Oxford University, where he wrote a dissertation on the semantics of indexical expressions. At Oxford, he was awarded the Henry Wilde Prize for Philosophy and the John Locke Prize in Mental Philosophy.

In addition, there have been changes in some continuing appointments. Professor Elizabeth Anderson was promoted from within our ranks last year to Associate Professor with tenure. Anderson works in ethics, political philosophy, and philosophy of economics and the social sciences. She has written on value pluralism, the ethical limitations of the market, social choice theory, and the relation of moral experience to moral theory. Her book, *Value in Ethics and in Economics*, is forthcoming from Harvard University Press.

David Hills, who has frequently been a visitor in the Department, will hold the position of Adjunct Assistant Professor beginning this year. He specializes in aesthetics, history of modern philosophy (especially Kant), and philosophy of mind. Jack Meiland, who served the College in administrative capacities for nearly fifteen years -- as Director of the Honors Program, and subsequently as Associate Dean for Long-Range Planning and Curriculum -- returned full-time to the Department this past year. It is good to have him back. On what is for us a less happy note, Gideon Rosen, who has been an Assistant Professor in the Department for four years, has accepted an offer at Princeton University. He has been a marvelous colleague and teacher. We wish him well.

There is much evidence of vitality and intellectual strength in our undergraduate and graduate programs. Last April, the Department awarded the second William K. Frankena Prize for excellence in the undergraduate concentration to Sara Ferguson. She is also the recipient of a National Endowment for the Humanities Younger Scholar's Award, working on "Obligation and Freedom in Kant's Ethics" under the supervision of Professor Stephen Darwall. Ferguson, who is a transfer student from Amherst, will graduate this January.

Eight graduating seniors wrote Honors theses this past academic year: Chris Bzdok, on "Theoretical Term Variation and Scientific Progress"; Adam DeVore, "Problematic Options Theory: An Assessment"; David Leitner, "Exploring Preemptive Suicide"; Michael Liem, "Race Conflict and the Objectivity of Historical Knowledge"; "Mark Linsenmayer, "Because We Are What We Are: An Account of Value as Self-Attribution"; Adam Meyerowitz, "The Will to Believe vs. The Ethics of Belief"; Adam Mosoff, "A Question of Obligation"; and Matthew Papa, "Engendering the History of Sexuality." An Honors thesis--a term's project, usually preceded by participation in an Undergraduate Honors Seminar--is a capstone to an undergraduate career. We congratulate these students.

The Undergraduate Philosophy Club was especially active this year. Under the leadership of Ferguson, Sheryl Gasser, Jeff Windsor, and Treasurer Raja Dakkuri, the Club held weekly evening meetings, often to hear and discuss a faculty presentation. The Club also designed and produced a highly successful Michigan Philosophy tee-shirt. A new Undergraduate Women's Philosophy Concentrators Group has been meeting for a number of months.

Among our graduate students, Justin D'Arms and Leon Porter were awarded Rackham Predoctoral Fellowships, in an increasingly stiff competition. (The stipend has been increased, but with a corresponding reduction in the number of awards.) Porter works in philosophical logic, on the semantic paradoxes. D'Arms' research concerns the bearing of evolutionary theory on ethics and moral psychology. D'Arms was also awarded a National Endowment for the Humanities Dissertation Grant (in the first year of the competition for this award), and a Charlotte Newcombe Fellowship. This was the seventh year in a row that a Michigan graduate student has been awarded a Newcombe. Though there is no expectation that students will have publications during their graduate careers, a number of students have been active in this area. D'Arms and Daniel Jacobson have a co-authored paper, "Expressivisim, Morality, and the Emotions," forthcoming in *Ethics*. Alexander Miller's "Truth, Permanence, and the Regulation of Doxastic Theory" is forthcoming in *Ratio*.

We look forward to the award of the first Charles L. Stevenson Prize for excellence in the graduate program this fall. The Prize is to be awarded for an outstanding "candidacy dossier," a portfolio of work expected to lead to a dissertation, and presented as part of the requirements for admission to candidacy. An endowment established by Marshall M. Weinberg, who graduated from Michigan with a B.A. in philosophy in 1950, funds both the Stevenson and Frankena Prizes.

Four of our graduate students who entered the job market this past year have accepted tenure-track positions for 1993-94: Sin-yee Chan (who works in ethics and Chinese philosophy) at Vermont, Eileen John (aesthetics) at Louisville, Brian Leiter (Nietzsche, ethics, and the philosophy of law) at University of San Diego School of Law, and Sigrun Svavarsdottir (ethics) at New York University. Of fifteen students who entered the market in the past three years, twelve have secured tenure-track positions, in philosophy or law. This is a superb record, in what has been a difficult market. I doubt that any major graduate program has been more successful in recent years. It remains the case that other highly deserving philosophers trained at Michigan have been less fortunate. This is a source of dismay for everyone here, and a loss -- we hope a temporary one -- both to the discipline and higher education.

For the second year in a row, graduate students organized the annual spring colloquium (our twelfth), and served as commentators on the talks. The topic was "Consciousness," and the speakers were Gilbert Harman (Princeton), David Rosenthal (Graduate School, City University of New York), and Robert Van Gulick (Syracuse). The commentators were Brad Chick (on Harman), Ted Hinchman (on Rosenthal), and Shane Schimpf (on Van Gulick). The present format provides an unusual opportunity for graduate students to contribute to philosophical discussion within the profession. Thanks are due to Professors Eric Lormand and Steve Yablo for their help in this project, and expecially to Jeff Kasser for his organizational work, and for tending to the outside speakers when a winter storm extended their "Spring" Colloquium visits.

Our Nelson Philosophers-in-Residence were Ruth Millikan and Hartry Field. Both visited for a week, delivered a public lecture, gave two seminars, and had numerous meetings with students and faculty. Other speakers, scheduled at intervals throughout the year, included Ned Block (Massachusetts Institute of Technology), Sarah Buss (Princeton), Eliot Sober (Wisconsin), Daniel Garber (Chicago), Susan Wolf (Johns Hopkins), and Penelope Maddy (Irvine). Anita Allen (Georgetown Law Center, Georgetown University), who received a Ph.D. in philosophy from Michigan in 1980, delivered a lecture on "Why Punish Demeaning Expression?" on the occasion of the University observance of Martin Luther King, Jr. Day.

Last year's Tanner Lecturer was Amos Oz, Professor of Hebrew Literature at Ben Gurion University. Oz has won numerous honors for his books, including England's Wingate Prize, and for his work in the cause of peace in the Middle East, including the Peace Prize of the City of Frankfurt. His novels include *To Know a Woman, My Michael,* and *Touch the Water, Touch the Wind.* Oz spoke on "The Israeli-Palestinian Conflict -- Tragedy, Comedy, and Cognitive Block." Although he subtitled his lecture "A Story-Teller's Point of View," it was a call to realistic engagement by Israelis and Palestinians. The participants in the Symposium on the Lecture were Rashid Khalidi (Director of the Center for Middle Eastern Studies at the University of Chicago), Anton Shammas (Adjunct Professor of Near Eastern Studies at Michigan), and Bernard Yack (Professor of Political Science at the University of Wisconsin).

There is much philosophical activity here independent of external, or classroom, stimulus. There have been joint graduate student and faculty discussion groups on aesthetics, feminism, and the work of Harvard ethicist Christine Korsgaard. There have also been lunchtime discussion groups in metaphysics and in ethics. This year, we saw a (modest) revival of the "faculty colloquium" -- with Steve Darwall and David Velleman presenting their work.

Some of you may have seen mention of the Department in a front page article in *The Wall Street Journal:* "Electronic Campus -- Technology Threatens to Shatter the World of College Textbooks" (June 1, 1993). The reference was to David Velleman's development of software for courses in elementary logic. Though our use of this software at this stage is experimental, we believe that computer-assisted logic instruction holds the prospect of significant educational benefits: instruction that is both self-paced and individualized, in that students might select among optional modules. Two of our graduate students, Nadeem Hussain and Krista Lawlor, have been actively involved in the development of the software. Professor James Joyce, and a third graduate student, José Zalabardo, have been experimenting with commerically available software in formal logic courses.

In April, we heard from the College that the Governor had recently authorized renovation of Angell Hall (and C. C. Little), and that construction would begin no later than January, 1994. For almost a half century, most of the Department's facilities have been located on the northern half of the second floor of Angell Hall. We do not expect this to change. We do expect both upgrading of basic systems, and some improvement in the space available to us for undergraduate and graduate instruction, graduate student work space, the Tanner Library, and faculty offices. All in all, we look forward to our new facilities, though not to the transition. Planning is somewhat fluid at this time, and a full report will have to wait until next year.

I hope this letter goes some way in updating you on philosophy at Michigan. We include in each issue of *Michigan Philosophy News*, in addition to the letter from the Chair, a philosophical article by a member of the faculty. We hope the pieces in this series will serve as stimulating reminders of the intellectual purpose and importance of our enterprise, and as a way of thanking friends and graduates for their support of philosophical education and research at Michigan. I thank Lawrence Sklar for contributing "Physics and Chance," in this issue. Professor Sklar, who specializes in the philosophy of physics, has a special gift for making material in this area accessible to non-specialists, without a sacrifice in intellectual rigor. You will find a biographical sketch at the end of his article.

In July, colleagues presented Stephen Darwall with copies of the 1737 edition of Lord Shaftesbury's *Characteristics* and the first, 1874, edition of Henry Sidgwick's *The Methods of Ethics*, in appreciation for his five year term as Department Chair. I want to express my personal thanks to Steve for his untiring and selfless service to the Department. (How many department chairs would travel to the airport to meet a prospective graduate student?) Opposing political currents in the academy made his term a difficult period. I am confident that Steve's leadership, and his commitment to philosophy at Michigan, have considerably strengthened the Department. For this, my job will be a lot easier. The great success of his most recent efforts in faculty recruitment is but one example of the ways in which this is so. Steve will have a well-deserved respite from administration and teaching during 1993-94; he will be completing his book on British moral philosophy from 1640-1740, with funding from a National Endowment for the Humanities Fellowship.

Sincerely,

Louis E. Loeb
Chair

August 15, 1993

PHYSICS AND CHANCE

1

Some philosophers of science explore issues of scientific method, seeking for general characteristics of the practice of science, whereas others explore the foundational features of particular theories in the sciences. What I would like to do here is introduce a few of the problems encountered when one explores a particular theory in contemporary physics, statistical mechanics, in order to illustrate how the problems of general methodology and those encountered in exploring the structure of a particular theory can interact.

Consider the notion of giving a scientific explanation of some phenomenon in the world. What, in general, is the structure of scientific explanations? One thing that has become clearer in recent years is that what we take to be the legitimate structure a scientific explanation can have is strongly influenced by the details of the kinds of theories we find it necessary to posit in order to grasp the features of the world.

In the mid-seventeenth century advanced thinkers thought, following Descartes, that all legitimate physical explanations of motion would require the positing of "contact forces." One object could be influenced into motion by another only if the objects actually collided with one another. Yet Newton found it necessary to posit gravity, a force acting "at a distance." The Cartesians could label such forces "occult" all they liked. The success of the Newtonian program legitimized talking about "action at a distance" as an explanatory component of physical theories.

Many special theories in the sciences bring with them their own special modes of explanation. Darwin's account of the origin of the species, for example, introduced variation followed by natural selection as the appropriate mode of explanation to offer to account for a species evolution. In the explanation of human behavior we talk about beliefs and desires, and much philosophical energy is spent in trying to understand just what kind of explanation for action we have provided when an action is accounted for in terms of the beliefs and desires of an agent.

2

Even in physics, however, we find theories whose mode of explanation doesn't look like that we are accustomed to in the main branches of physics. In simple problems of mechanics, the fundamental theory of motion and its causes, we expect an explanation to look like this: An initial state for a system is posited. It is shown that from that initial state certain later states must follow according to the fundamental dynamical laws of mechanics. So we can explain those later states as "caused" by the initial state, the causal linkage being summarized in the lawlike regularity connecting the states.

But things aren't always that straight-forward. Consider, for example, the important theories of thermodynamics and statistical mechanics. In order to deal with the phenomenon of heat and its interaction with mechanical work, matters so vitally important to the development of the Industrial Revolution with its foundation in the steam engine, physicists introduced new concepts to deal with the physics of heat. Concepts such as that of temperature, heat flow and entropy supplemented the older mechanical concepts like position, momentum, acceleration and force. With great ingenuity laws were found that governed the interaction of heat and energy in the form of usable mechanical work.

In the nineteenth century, however, great new insights were obtained by developing the idea that macroscopic objects were made of a vast number of microscopic parts (such as the molecules of a gas), and that the laws governing heat and its transformations really dealt with the way in which the energy of motion of the microscopic parts was distributed among those parts. The ideas here dated back for centuries in hints and guesses, but achieved their full splendor in the work of J. C. Maxwell and L. Boltzmann in the middle to end of the nineteenth century. It was in framing this new theory of heat and its transformations that novel explanatory modes were introduced into physics.

3

In thermodynamics a particularly important notion is that of the equilibrium state of a system. Systems arranged in some thermodynamic state will, if left to themselves, change that state until they reach a certain special condition, the equilibrium state. Once having obtained the equilibrium condition, however, they stay in that "preferred" state forever. For example, an iron bar initially hot at one end and cold at the other will have heat flow in it until it is of an even temperature all over. It will then remain in this equilibrium state if left undisturbed.

What is the equilibrium state? Why do systems not in it approach it? And why is it alone the one time-invariant state of an isolated system? In the new atomistic version of the theory the equilibrium state is, crudely, the one in which the internal energy of motion of the molecules is distributed over the molecules in such a way that the distribution remains unchanged as the molecules collide with one another. Even though in each individual collision some molecule slows down and another speeds up, in the equilibrium distribution the net result of collisions is to retain a constant distribution of energy over the various possible speeds a molecule can have. For any other distribution of molecular speeds, collisions redistribute speeds until the equilibrium distribution is reached. The high point of Boltzmann's work was his famous equation showing how such redistribution takes place and how systems originally not in equilibrium will get there.

Here is where things get interesting. Boltzmann seemed to have shown that any system not in the equilibrium state must go to the equilibrium state and stay there. However, if one examines the laws that govern the motion and interaction of the molecules, it is easy to show that if it is possible for a system to go from non-equilibrium to equilibrium, then it must be possible for transitions from equilibrium to non-equilibrium to occur as well. Boltzmann's initial response to this objection was to assert that his equation didn't describe the inevitable behavior of systems, but only that behavior which was "probable." Both he and Maxwell realized that only by introducing probabilistic notions and explanations framed in the mode of probability could the theory be made consistent with the underlying dynamical theory of molecular motion.

But what is "probability?" What exactly do probabilistic assertions *mean*? How do probabilistic claims function to describe the world from the scientific point of view? What is it to "probabilistically explain" some physical phenomenon in the world? Here we see just the sort of questions that will make a philosopher of science sit up and take notice. The Maxwell-Boltzmann theory is the first to introduce probabilistic notions into physics at a fundamental level. The sorting out of the notions introduced and the project of understanding just what probability is and how it functions in fundamental scientific theories has led to an ongoing inquiry at the hands both of the scientists and the philosophers.

4

From the very beginning Boltzmann's introduction of probability into his account led to questions. One interpretation of his claim is that his equation showed how almost all systems must behave in time, going from non-equilibrium to equilibrium. But that is a very problematic claim. There are deep arguments designed to show not only that the transition from equilibrium to non-equilibrium is possible, but that the chance of a move from equilibrium to non-equilibrium must equal the chance of a move in the other direction. So how could moves toward equilibrium be "overwhelmingly most probable?" Other deep arguments show that a system started in a non-equilibrium state must, sooner or later if kept isolated for long periods of time, come back to a state arbitrarily close to that in which it started. Once again this makes a claim of "overwhelming probability" for irreversible movement from non-equilibrium to equilibrium seem dubious.

Responding to these objections Boltzmann clarified his claims. The equilibrium state, he said, is the one that is the "overwhelmingly most probable" state of the system. Looked at over infinite time a system will almost always be in or near equilibrium. There will, however, be "excursions" away from equilibrium on the part of the system. The further from equilibrium one gets, the rarer will be the occasions in which the system reaches that state. But there will be equal numbers of transitions in any one time direction toward and away from equilibrium.

This picture of the world is itself one that immediately gives rise to complaints. If equilibrium is the "overwhelmingly probable" state of systems, why do we find ourselves in a universe in which non-equilibrium is overwhelmingly dominant? Our cosmos, with its hot stars shining into cold space is very, very far from the uniform temperature condition of equilibrium. Furthermore, Boltzmann's final version of his theory is one that is symmetric in time, with systems moving toward and away from equilibrium with equal probability. But the world we experience, the world described by thermodynamics, is one that is radically asymmetric in time, with systems heading toward equilibrium into the future and never into the past. Hasn't something gone very wrong here?

Boltzmann's response to these objections is brilliant and astonishing, even though, in its original form we now think it cannot be true. Imagine, he says, a universe that is very large in space and long-lived in time. Most of it will be in the dominant equilibrium condition most of the time. But there will be "small" regions that for "short" periods of time will be far from equilibrium. We live in one such region. Indeed, only in such non-equilibrium regions could sentient organisms evolve. This is because the energy flows needed to sustain a complex life-form can only exist in non-equilibrium conditions. So our impression of a universe far from equilibrium is a parochial mistake on our part. It is only our neighborhood that is far from equilibrium. But why do we see the universe heading toward equilibrium in the future direction of time, and not heading away from an equilibrium state in the past? Boltzmann argues that we take systems to be approaching equilibrium in the future direction of time, and not in the past direction, because what we mean by the future time direction is that direction in time picked out by the direction of time in which most systems are approaching the equilibrium condition.

5

Naturally these astonishing claims of Boltzmann have attracted a great deal of attention and discussion. Placed in the context of our contemporary understanding of the structure of the universe, they cannot be correct as they stand. But a variety of "neo-Boltzmannian" ideas exist and the discussion of them is ongoing and animated.

I want to focus here, however, on a narrower problem, one that will allow us to get some idea of how scientific and philosophical concerns intersect in exploring the foundations of the Maxwell-Boltzmann theory, the theory of statistical mechanics.

We noted earlier that Boltzmann described the equilibrium condition as the one characterized by the "overwhelmingly most probable" distribution of energy among the molecules. But what does this mean? What is the "probability" of a molecular distribution and why is the equilibrium distribution "most probable."

There are actually a variety of ways in which one can try to characterize the probability of a molecular distribution. A method invented by Maxwell and Boltzmann and made the core of the theory by J. Gibbs is the most profound technique. One thinks of an abstract space of many dimensions. In this space a single point represents the total molecular condition of a gas subject to some macroscopic constraints (like being in a fixed size box and having a fixed energy). Regions of points in this space are assigned numbers between zero and one as "sizes," with the total allowed space getting size one. One then thinks of the size of a region as giving the probability that the molecules of the system will have a condition corresponding to the point representing that condition being in the region. To understand this, think of throwing darts at random at a dart board. The probability that a dart will land in a specific region of the board is proportional to the area of that region.

But how are sizes to be assigned to the regions? There is a procedure for doing so that is standard. It has the special virtue that the size assigned to a region will remain invariant in time as the points representing systems "flow" in a manner that represents how the systems evolve under the laws of dynamics as time goes on. Equilibrium is then thought of as being characterized by this special probability distribution. One can then show that if one identifies equilibrium values of macroscopic features of the system with quantities computed from the molecular distributions, the equilibrium values of these quantities will indeed be "overwhelmingly probable" in the given probability measure.

But there is something peculiar here. One simply picked that probability measure. Could one pick a different measure, one that would make the equilibrium values highly improbable? What is so special or natural about the measure one picked that makes it the "right" probability distribution? For that matter, what is it that the chosen probability distribution is describing?

One way of answering that last question asks us to imagine an infinite collection of systems. Each system in the collection will be characterized by the same macroscopic features, but the systems will have differing microscopic arrangements of their molecules. The probability distribution, then, is supposed to tell us with just what proportion a given kind of molecular distribution will appear in this collection. But such a picture of "all possible systems of a given kind," is just a picture. There aren't such infinite collections of systems in the world. So what does the probability distribution really describe?

6

One ingenious but non-orthodox suggestion, by E. Jaynes, takes probability as it appears in statistical mechanics to be like the probability discussed in philosophical theories of rational belief. It is a measure of the reasonableness with which we are to "bet" on a certain propositions coming out true. Probability is here thought of as a measure of a subjective state, a degree of belief.

In many such theories of "subjective probability," one determines the probability to attribute to some proposition by using a kind of symmetry argument. Think, for example, of tossing a fair die. It has six "symmetric" possible outcomes, depending upon which face comes out up. So we ought, according to this theory, to attribute a probability of one-sixth to any specific outcome, say a one coming up on the toss. Jaynes argues that one can justify the probabilities used in statistical mechanics on just such reasoning from lack of knowledge of what the exact state is and a symmetry principle over the states.

But such arguments are questionable. And for very "philosophical" reasons. Suppose I think of the die as having two possible outcomes: "a one comes up," versus "any other number comes up." Then there are two cases and I should give a one coming up a probability of one-half! What makes one way of classifying possible outcomes legitimate and others illegitimate? One gains insights into the nature of the theory of statistical mechanics by exploring the possible answers to such questions, possible answers deeply connected to the kinds of answers familiar to philosophers who search for the foundations of inductive reasoning.

7

A more popular answer to the question about just what probabilities in statistical mechanics are relies upon the close association of probabilities with frequencies or proportions of outcomes. Don't we take the probability of a one coming up on a die to be one-sixth because in a long series of tosses the one will come up about one-sixth of the time?

In the early days of statistical mechanics Boltzmann frequently emphasized the fact that his understanding of probabilities required that they be understood in terms of frequencies or proportions, especially frequencies and proportions over time. To say, then, that the standard probability distribution correctly described equilibrium meant, for Boltzmann, that if we looked at an isolated system over a long period of time, the proportion of time in which the system had a given kind of microscopic distribution for its molecules would be correctly given by the probability assigned that kind of distribution by the standard probability distribution.

But, then, showing that the standard distribution was correct would require showing that it did represent the proportions over time correctly. How could such a demonstration be made? Maxwell and Boltzmann introduced what is called an Ergodic Hypothesis. In one version, it says that if we leave a system isolated for an infinite time, its molecular state will eventually go through every possible molecular state compatible with the constraints on the system. Such a postulate will allow you to claim that the standard probability distribution correctly captures proportions over time. Alas, the Ergodic Hypothesis is provably false in its strong form.

But it can be "patched up," although the patching job takes nearly a century and requires the invention of a whole new field of mathematics, so-called ergodic theory. What is finally unveiled is this: There is a mathematical condition that is sufficient to guarantee that the proportion of time that a system spends in a set of microscopic conditions over an infinite time will equal the proportions of those conditions described by the standard probability distribution. At least this will be so except, possibly, for a collection of systems that has "probability zero" in the standard probability measure. Then one can show that an idealized system something like the physical systems of interest to scientists meets the required mathematical condition. The reason this is so is because in the idealized system there is a high sensitivity of the future of the system to its initial state. This kind of instability of motion at the microscopic level is just the sort of thing one needs to get the results one wanted.

With these results, then, one can show that for systems of the appropriate kind, the time proportion of microscopic states will, over infinite time, be the proportion of those states in the standard probability distribution. So we can connect "probability" as an abstract concept in the theory with some kind of expected frequency or proportion of a system in the world. And from the fact that the system has a vast number of molecules, and from a few other relevant facts, one can finally show that Boltzmann was right in claiming that the molecular distributions corresponding to equilibrium are "overwhelmingly dominant in time."

8

But it is at just this point that there is work for the philosopher of science. Just what kind of *explanation* of the existence and nature of equilibrium have we been provided by this theory? Does it look like the sorts of things called explanation, even those called probabilistic or statistical explanation, in our philosophy of science texts? What the theory shows is that over infinite time the dominant amount of time spent by the system will be in the states of molecular distribution that correspond to the observed equilibrium states of experimental science. At least this will be so if the system is not one of the "exceptional" systems of probability zero that violate this condition.

But observed equilibrium states are not states "dominant over an infinite amount of time." Instead they are the (apparently) stable and unchanging states over experimental times that are reached by systems in a definite experimental time in the laboratory. The ergodic results have done something for us. They have associated the mysterious abstract standard probability measure with something more like a physical feature, proportion of time in the infinite time limit. But the results only hold for idealized systems, and most realistic physical systems fail to meet the ideal conditions. Finally, even when the idealization is met the results may fail to hold for "improbable" systems. But these systems are "improbable" only in the sense that the standard probability distribution declares them improbable. And it was the justification for choosing that probability in the first place that was in question.

Most importantly, the results obtained require us to think of what happens "in the limit as time goes to infinity." This "infinite" time limit is essential for the result, and nothing in the result lets us substitute for it some large but finite time.

What we have come upon here is something well known to philosophers of science, but something whose importance is often underestimated. Science always "idealizes" physical systems to get its results. Sometimes these idealizations are "controllable," in the sense that we can estimate well the degree of error we have introduced into our description of the real world by going to our idealization. But sometimes, the case of statistical mechanics being one of those times, idealizations are "uncontrollable." They are essential to obtain the results we want, and we cannot systematically tell how much "error" has been introduced in going to our idealized picture. Further exploration of statistical mechanics shows this phenomenon of "uncontrollable idealization" to occur in many different contexts.

The very meaning of what we are claiming when we claim that a state of a system has a certain degree of "probability," where this probability is to be interpreted as some kind of frequency or proportion in the world, is subtly changed when the notion of proportion we are dealing with is proportion in some idealized context not actually constructible in the world. And the notion of statistical explanation we are using when we explain a phenomenon by showing, perhaps, that it was to be expected with high probability, also is subtly modified when it is not the behavior of real systems that we are dealing with, but instead the idealized features of idealized systems. By exploring the detailed structure of concrete physical theories, such as the structure of statistical mechanics, we gain insight into just how complex our philosophical notions of explanation will have to be to do justice to what actually counts as giving an explanation by means of a theory in real, foundational science.

Lawrence Sklar
1993

References

A non-technical introduction to the problems discussed in this piece is chap. 3 of L. Sklar, *Philosophy of Physics*, Westview Press, Boulder, 1992. The problems are discussed more technically and in greater depth in L. Sklar, *Physics and Chance: Philosophical Issues in the Foundations of Statistical Mechanics*, Cambridge University Press, Cambridge, 1993.

Well chosen selections from the original works of Maxwell, Boltzmann and others, translated into English where necessary, have been collected in S. Brush, *Kinetic Theory*, Pergamon Press, Oxford, 1965.

For more on the relevant physics, try P. Davies, *The Physics of Time Asymmetry*, University of California Press, Berkeley, 1974. For more on some related philosophical issues see P. Horwich, *Asymmetries in Time*, MIT Press, Cambridge MA, 1987.

For more on the vagaries of idealization in science see N. Cartwright, *How the Laws of Physics Lie*, Oxford University Press, Oxford, 1983.

Lawrence Sklar joined the Department in 1968-69. He holds a B.A. from Oberlin College, and a Ph.D. from Princeton University. Professor Sklar is a specialist in philosophy of physics, philosophy of science, and epistemology. He was awarded the Franklin J. Matchette Prize in philosophy for 1973-74 for his first book, *Space, Time and Spacetime*. He has since published *Philosophy and Spacetime Physics* and *Philosophy of Physics*. His *Physics and Chance* is forthcoming from Cambridge Universty Press. He has published numerous articles on such topics as the nature of theories, structures for rational belief, intertheoretic reduction, the philosohpy of space and time and philosophical issues in statistical mechanics. He has held fellowships from the Guggenheim Foundation, the American Council of Learned Societies, and the National Science Foundation. He has taught at Swarthmore, Illinois, Princeton, Pennsylvania, Harvard, UCLA, and Wayne State. At Michigan, he is a Grace B. and James J. Nelson Fellow in Philosophy.

CONTRIBUTIONS

The Department acknowledges with gratitude the following contributors during the period July 1, 1992 through June 30, 1993.

Endowment Contributions

Malcom L. Denise, B.A. '35, J.D. '37, for the enhancement of the Denise Philosophy Endowment, honoring Theodore C. Denise, B.A. '42, Ph.D. '55.

Marshall M. Weinberg, B.A., '50, for the enhancement of the Marshall M. Weinberg Endowment for the William K. Frankena and Charles L. Stevenson Prizes.

Annual Fund Contributions

Michael Paul Adams, Ph.D., '88
Richard M. Adler, B.S., '74
Hugh Barry Anderson, J.D., '58
Al Armenti, Ph.D., '59
Jeffrey Dean Barnett, B.A., '81
Fred Lester Bartman, Ph.D., '67
Howard and Joan A. Binkow, B.A., '64
Adam F. Bovone, B.A., '91
George G. Brenkert, Ph.D., '71
James Allen Brown, M.A., '75
Lee Miller Brown, Ph.D., '86
Juliet T. Browne, B.A., '84
Brenda M. Brush, Ph.D., '61
Edgar V. Cano, B.A., '86
Lindsay D. Chaney, B.A., '73
Roger Bruce Cole, B.A., '53
Diana R. Czerwinski, B.A., '63
James Andre Dehullu, B.A., '67
Gary Clark Dolan, B.A., '76
David P. Dyer, M.A., '69
Thomas David Eisele, Ph.D., '84
Carol S. Feldman, Ph.D., '68
Scott Lee Fogo, B.A., '71
Samuel Denis Fohr, Ph.D.,'86
Robert George Foster, B.A., '66
John F. Gajewski, M.B.A., '81
Jeffrey A. Gallant, J.D., '90
John C. Garrett, B.A., '64
John Thomas Granrose, Ph.D., '66
Andrew Evan Green, B.A., '79
Sarah Griffith, B.A., '77
Lawrence A. Gross, J.D., '79
Louis M. Guenin, B.A., '72
Charles T. Hagen, Ph.D., '81
Helen Wixson Hall, M.S., '78
Randall Ross Hall, J.D., '78

Peter V. Hamill, M.D., '53
Charles A. Henry, B.A., '88
Timothy Jon Howard, B.A., '74
Paul Manson Hurrell, Ph.D., '61
John Raymond Immerwahr, Ph.D., '72
Carolyn Tanner Irish, B.A., '62
Mark Alan Jarboe, B.A., '72
Richard C. Kaufman, B.A., '73
Stanley B. Kay, M.A., '58
John Malcolm Kelson, B.A., '65
William L. Kime, M.A., '63
Joan Frances Kintzing, B.A., '45
Michael J. Kump, J.D., '81
James Edward Labes, B.A., '54
Albert S. Lacy, B.A., '79
Roger Allan Lane, B.A., '84
Martin Seth Lederman, B.A., '83
Mark Alan Levensky, Ph.D., '66
Kurt Joseph Levitus. B.A., '85
Margaret J. Livingston, B.A., '75
Lynne D. Mapes-Riordan, B.A., '85
Anneliese F. Mauch, B.A., '86
C. Jeffrey McLean, B.A., '71
Gary Joseph Miller, M.B.A., '80
Harlan B. Miller, M.A., '63
Theodore N. Miller, B.A., '64
Dianne F. Morgan, B.A., '73
Frank Aaron Morrow, Ph.D., '64
Daniel Osher Nathan, B.A., '69
Larry M. Nemer, M.A., '79
Orville W. Nyblade, B.A., '50
Angelina G. Overvold, M.A., '74
William A. Paton, Ph.D., '54
James L. Reus, M.D., '77
Joel F. Richeimer, Ph.D., '92
John Giles Roberts, B.A., '49
Eleanor Rosenthal, B.A., '54
Craig A. Rowley, B.A., '76
Michelene T. Sager, B.A., '88
Dion James Scott-Kakures, Ph.D., '88
Daniel Sedey, Ph.D., '69
Peter Max Serling, B.A. RES, '81
Amy Lynn Shapiro, B.A., '77
Steven Joel Shaw, B.A., '63
Thomas Tyler Skrentny, M.D., '58
David Craig Slawson, M.D., '81
John Andrew Sotiroff, B.A., '89
Keith A. Sotiroff, B.A., '86
Colleen A. M. Stameshkin, Ph.D., '76
R. Gregroy Taylor, B.A., '73
Stephen George Vanmeter, B.A., '83
Virginia L. Warren, Ph.D., '79
Renee R.Wasserman, B.A., '82
Paul Yin Hwa Yu, Ph.D., '73
Michael A. Zimmerman, B.A., '63

Matching Gifts

Audience Concepts, Dayton, OH
Digital Equipment Corporation, Maynard, MA
Merrill Lynch & Co., Foundation, Inc., New York, NY
Shell Oil Company Foundation, Houston, TX
US West Foundation, Englewood, CO

In Kind Contributions to the Tanner Philosophical Library

Anonymous
Stephen Darwall
Michael S. Davis, Ph.D., '72
James Joyce
Kendall Walton
Crispin Wright

FACULTY, 1993-94

Elizabeth Anderson*; Associate Professor; Ethics, Political Philosophy, Philosophy of Economics and the Social Sciences

Frithjof H. Bergmann; Professor; Existentialism, Nineteenth Century Philosophy, Social Philosophy, Philosophy in Literature, Philosophy of Mind

Richard B. Brandt; Professor Emeritus; Ethics, Epistemology, Philosophy of Mind

Arthur W. Burks; Professor Emeritus; Philosophy of Science, Logic, Automata Theory

Edwin Curley; Professor and James B. and Grace J. Nelson Fellow; History of Modern Philosophy

Stephen L. Darwall*; Professor; Moral and Political Philosophy, History of Ethics

Paul Franks; Assistant Professor; Michigan Society of Fellows; Kant, German Idealism, Ordinary Language Philosophy, Maimonides and Medieval Jewish Philosophy

William K. Frankena; Professor Emeritus; History of Ethics, Ethics, Moral Philosophy

Allan F. Gibbard; Richard B. Brandt Professor and James B. and Grace J. Nelson Fellow; Ethics, Social Choice Theory, Decision Theory, Metaphysics, Philosophy of Language

Sally Haslanger; Associate Professor; Metaphysics, Epistemology, Ancient Philosophy, Feminist Theory

David J. Hills; Adjunct Assistant Professor; Aesthetics, History of Modern Philosophy, Philosophy of Mind

James Joyce; Assistant Professor; Decision Theory, Philosophy of Science

Louis E. Loeb; Professor; History of Modern Philosophy

Eric Lormand; Assistant Professor; Philosophy of Mind, Philosophy of Cognitive Science, Epistemology

George I. Mavrodes; Professor; Philosophy of Religion, Social Philosophy

Jack W. Meiland; Professor; Metaphysics, Philosophy of Mind, Continental Philosophy, Philosophy of History and Social Science

Donald J. Munro; Professor; Oriental Philosophy

Peter A. Railton; Professor and James B. and Grace J. Nelson Fellow; Ethics, Philosophy of Science, Political Philosophy

Donald H. Regan; Professor and Professor of Law; Moral and Political Philosophy

Ian Rumfitt; Assistant Professor; Philosophy of Language, Philosophical Logic, Philosophy and Linguistics

Lawrence Sklar; Professor and James B. and Grace J. Nelson Fellow; Philosophy of Physics, Philosophy of Science, Epistemology

J. David Velleman; Associate Professor; Ethics, Philosophy of Mind, Philosophy of Action, Pragmatism

Kendall L. Walton; Professor and James B. and Grace J. Nelson Fellow; Aesthetics, Philosophy of Mind, Metaphysics, Epistemology

Nicholas P. White; Professor; Ancient Philosophy, Metaphysics

Crispin Wright*; James B. and Grace J. Nelson Professor; Philosophy of Language, Metaphysics, Philosophy of Mathematics, Wittgenstein, Epistemology

Stephen Yablo; Associate Professor; Metaphysics, Epistemology, Philosophy of Mind, Philosophical Logic

*on leave all or part of year