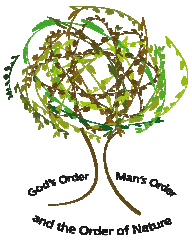
ISSN 2045-5577



ORDER: GOD'S, MAN'S AND NATURE'S

Cooperation, Conflicts and Compromises: Epistemic and Non-Epistemic Pluralism and Interactionism in a Critical Moral, Political, and Cognitive Philosophy o0f Science

Jordi Cat

Department of History and Philosophy of Science

Indiana University
drjordicat@yahoo.com

1. Introduction. Not explicate, but complicate.

The natural philosopher James Clerk Maxwell posits that scientists are preoccupied with explications and leave to metaphysicians the business of complication. In this paper I am prepared to take up the task and suggest that complication of the right sort, with or without metaphysical speculation, may provide an effective philosophical remedy for the poverty of reductionism. My aim is to complicate the possible typologies and perspectives applied to the connection between scientific disciplines, their projects and practitioners, so they can be understood, re-imagined and guided more intelligently, reflectively, creatively and fruitfully. To that effect, one must understand the business of scientific boundaries and cooperation, of unity of science, with a human face and with the sensibility for the right sort of additional considerations that can be found in other areas of inquiry, including philosophy. A human philosophy of science requires, for instance, that matters of unity (and disunity) of science and unity (and disunity) of philosophy be figured out and worked out hand in hand. In this case to illuminate and guide particular kinds of interaction and cooperation and science, I appeal to historical analysis and to moral and political philosophy. Revising and enriching our conception of the past may become a useful tool for altering, enriching and bringing about our conceptions of the future. Specifically, I note and discuss the role of compromise as a neglected link between unavoidable conflict and desirable cooperation. A compromise-based framework for understanding scientific research can accommodate not just the moral and political dimensions of science that moral and political philosophy help illuminate, it also does justice to cognitive or methodological attitudes and commitments that scientists take for granted, for instance, the rejection of absolute precision and completeness and the interest, instead, in the values of idealization and approximation central to modeling and computational techniques.

2. Complication and conflict.

I begin by briefly taking stock of ideas I have presented and discussed elsewhere. The problems of rigidity and dogmatism in stolid preconceptions scientific unity and boundaries, also the weakness of vague intuitions, can be remedied. But they must be subjected to two interpretive perspectives: historical distance and complexity and philosophical discrimination. As models of connection in science, unity and reduction have a history, and this history is a history of diversity. Each position may be understood within its own context, even in relation to specific alternatives and to the ongoing discussion of the time-honored problematic of the one and the many or in genealogical unity of descent from it.

The following is one attempt at presenting such diversity:[1]

1. *Historical development in philosophy and science from Greek philosophy to Logical Empiricism in America*

1.1. From Greek thought to Western science
1.2. Rationalism and Enlightenment
1.3. German tradition since Kant
1.4. Unity and reductionism in logical empiricism
1.5. Unity and reduction in logical empiricism in America: Postwar orthodoxy in philosophy of science

2. *Recent and contemporary debates in science and philosophy since the1960s*

2.1. Antireductionism in the 1960s

2.2. Neo-reductionism in philosophy of science

2.2.1. Schaffner
2.2.2. Glymour
2.2.3. Nickles
2.2.4. Fodor
2.2.5. Sarkar
2.2.6. Semantic and model-theoretic approach
2.2.7. Reductionism without laws or theories: Spector and Wimsatt
2.2.8. Eliminativism

2.3. Metaphysics

2.4. Epistemology informal and formal: unity, explanation and understanding

[1] Cat 2007.

2.4.1. Unity, explanation and understanding
2.4.2. Unity, methodology and simplicity
2.4.3. Unity in formal epistemology

2.5. Non-reductive models of unity
2.5.1. Introduction
2.5.2. Interfield theories
2.5.3. Cross-classification categories
2.5.4. Downward developments
2.5.5. Interdependence
2.5.6. Heuristic, pragmatic and categorial interrelations
2.5.7. Field Interconnection
2.5.8. Historical and genealogical unification
2.5.9. Hybridization
2.5.10. Local integration or coordination and trading zones
2.5.11. Material unity

2.6. Disunity
2.6.1. Introduction
2.6.2. The Stanford School
2.6.3. Dupré
2.6.4. Cartwright
2.6.5. Disunity and metaphysics
2.6.6. Pluralism

2.7. The Sciences
2.7.1. Introduction
2.7.2. Physics
2.7.3. Chemistry
2.7.4. Biology
2.7.5. Human sciences, psychological and social
2.7.6. Complexity

3. Why unity? And, What difference does it really make?

A different take must challenge the notion that laws are epistemic ideals, the privileged units of scientific knowledge, and, as such, the rightful relata in the connections between different sciences. As I have argued elsewhere, attention to scientific models in different sciences, including physics itself, suggests otherwise. And to look to the 'hard' cases of physics is particularly important because much is made of the fact that lessons from cases from higher-level sciences such as biology

or economics do not carry the same philosophical weight. The cases from macroscopic materials science to fundamental quantum field theory, the phenomena, among others, of symmetry-breaking, suggest that the cognitive role is either importantly shared with or predominantly performed by what I have called anomic elements, e.g., boundary conditions, structures and mechanisms.[2] These are either not reducible to laws or not functionally replaceable by them.

Attention to the relation of laws to models shows further that the constructive and semantic assumption that laws are trivially satisfied by models –a view with long hold upon philosophy of science, from Tarski and Suppes to Cartwright and Giere- is hardly exact.[3] Internal degrees of approximation provide a measure of the gap between the scope of application –and validity- of the law and that of the models. More problematic still is the situation in which the cognitive values, representational, explanatory and predictive, of the model -for instance, models of dynamics of fracture in the form of crack propagation- rely on inconsistencies between laws and other assumptions. The assumptions contradicted include pre-conditions for the validity of the laws in the model, such that, one may say, the scope of application of the models outreaches the scope of validity of the laws.[4] Such conceptual inconsistencies suggest two lessons germane to the topic at hand: they undermine the fiction that fundamental laws can neatly reproduce phenomena as best describe by less fundamental 'representations'; and the place epistemic conflict neatly within the theoretical core of science. The second lesson reaches beyond the image of science that since Duhem and Neurath –e.g., the so-called Neurath Principle- and their problem of falsification of hypotheses (with or without the holism about cluster of auxiliary hypotheses), and later Kuhn, has

[2] Cat 2005. I oppose the centrality of laws adopted in accounts as recent as the law-based philosophy of biology in Mitchell 2009.
[3] Ibid.
[4] Ibid. See also instances reasoning from inconsistent information in classical electrodynamics in Frisch 2005, and in thermodynamics, in Meheus 2002.

placed conflict and crisis at the core of our images of scientific methodology and the dynamics of science (see below).[5]

Precisely to address the so-called Duhem-Quine problem of (logical) holism in test (and interpretation) situations, recent literature has defended the value of the related notions of models and simulations.[6] Models, as constructed idealizations, are meant to operate as wedges that analyze a more complex theory into parts that can logically receive praise or blame. This strategy, however, misses the irreducible complexity of experiments, models and simulations that is intrinsic to their constructed nature.[7] A more fundamental failure of perspective is the ensuing failure to understand the synthetic methodology behind the efforts to synthesize individual experiments and models themselves and to synthesize models together.

The synthetic strategy, beyond the synthetic spirit that defines the unity of science problem, has proved both challenging and rewarding in the small scale especially since the Second World War.[8] From a conceptual standpoint, it stands to reason, and to empirical evidence, that self-contained disciplines are bound to exhaust their internal resources. Interaction is then the path to innovation. One of the challenges stems from models involving non-overlapping assumptions or incompatible assumptions; in other words, modeling involves conceptual and methodological inconsistencies or conflict. Modeling from the standpoint of the synthetic strategy that encourages alliance and cooperation requires reaching beyond naïve additive or aggregative assumptions and acknowledging diversity and conflict.

3. James Clerk Maxwell and the connected sciences.

Detailed historical analysis illustrates the value of the complexity of the synthetic approach. Few scientists have reached such a broad and lasting achievement as James Clerk Maxwell did on the premise of a synthetic attitude to

[5] On the Neurath Principle and conflict between hypotheses and data see Cat 1995 and Cartwright, Cat, Fleck and Uebel 1996. Kuhn's dynamics of the demise of scientific paradigms offers a dramatic instance. On the dynamical role of inconsistency, see Meheus 2002.
[6] Barberousse and Ludwig 2009.
[7] Cat and Gennaro, forthcoming.
[8] Ibid., and Cat 2007.

the advancement of understanding. Yet, on close examination, the connective character of his scientific work had a diversity of dimensions and sources, reductive and non-reductive, theoretical and non-theoretical. Dimensions include theoretical modeling, material modeling, experimentation, and methodology; sources include philosophy, theology, natural history, design, and engineering.

In 1878, Maxwell was invited to deliver the University of Cambridge's Rede Lecture, in the long wake of Darwin's discussion of orchids of 1862 (with surprising impact on the acceptability of cousin-marriages), and of the more recent successful patent applications concerning telephone technology by the fellow Scotch Alexander Graham Bell and the American Thomas Edison. In his lecture Maxwell declared that 'the telephone is an instance of the benefit derived from the cross-fertilization of the sciences.'[9] The telephone was 'a material symbol' of 'the widely separated departments of human knowledge, the cultivation of which has led, by as many converging paths, to the invention of this instrument.'[10] It was a material symbol, more generally, of the 'unity of science itself', 'the paths of communication between isolated departments of human knowledge' and 'the communion of the workers in science' that the University, like the international scientific community, could be.[11] It was also a material symbol of Maxwell's own scientific practice, on the premise that ultimately science 'exists only in the mind, and the union of the sciences can take place only in a living person.'[12] Maxwell's practice, by 1878, was firmly anchored in the direction of Cambridge's Devonshire Physical Laboratory, and integrated both the abstract and the concrete, the theoretical and experimental, philosophical and material, mental and bodily, under the rubric of work.

A cursory look at his four decades of scientific work, to employ a term he would have accepted, provides the following partial selection of instances of connective paths. Here are the main points.

(1) Non-reductive:

[9] Maxwell 1878 in Maxwell 1890, SP vol 2, 751.
[10] Ibid.
[11] Ibid., 743 and 754.
[12] Ibid., 751.

*Theoretical and topological connections: ornamental designs and topological relations; equations relating electric and magnetic properties and 'mutually embracing' electric and magnetic curves.

*Shared values: generality and precision of representation, truth, support by confirmed experimental result.

*Modeling situations in one discipline in order to model and solve problems in another, for instance, physical analogies between continuum mechanics and electromagnetism.

*Transfer and endorsement of concepts and tools: field concepts from estate management, color theory and physiology of vision to electromagnetism; statistical and historical methods and notions (Quetelet, Buckle) from social sciences to molecular theory of gases; Whewell's philosophical notion of fundamental idea organizing many of his papers and theories; rhetorical elements such as figures of speech understood as figures of thought and formulated as scientific methods such as the methods of physical analogy and scientific metaphor.

*Material-cognitive series: molecular series of models connecting rings of Saturn to electromagnetic ether; spinning series: models of spinning and circulating systems connecting theories and experiments: from rotation to color top, rings of Saturn to circulation of electricity and cinematographic models of fluid flows (see figure below).[13]

[13] See Cat forthcoming.

(2) Reductive:

*Molecular models of gases with alleged identity between mechanical properties of molecules and thermodynamical properties of gases.

*Molecular models of electromagnetic ether; innovation here rests on inconsistency, namely, a conflict between the discreteness of the molecular of the ether as a machine as system of connected parts and the continuity of the electromagnetic and mechanical field properties.

*Identity of electromagnetic and light waves, electromagnetism and optics.

*Method of theoretical speculation or generalized model of reduction: high probability in reductive generalizations –general principles- without reductive models. The generalizations operate as higher probability placeholders for unreliable hypothesis about particular models of microscopic entities and connecting mechanisms.[14] Maxwell writes in the same terms about the method of hypothesis in *Matter and Method* in the same context of dynamical explanation:

'The success of this method depends on *the generality of the hypothesis* to begin with. If out hypothesis is the extremely general one that the phenomena to be investigated depend on the configuration and motion of a material system, then if

[14] There is a shift in Maxwell's use and value of generality from early Edinburgh logic and scientific ideal (Hamilton, after Aristotle and Kant) and Cambridge culture of generality in logic& methodology (Whewell, Mill) and algebra as generalized form (Peacock, Kelland).

we are able to deduce any available results from such a hypothesis, we may safely apply them to the phenomena before us.'[15] He concluded: 'It is therefore of the greatest importance in all physical inquiries that we should be thoroughly acquainted with *the most general properties* of material systems.'[16]

The connective perspective on the unity of science as aim and method can been seen as being multiply grounded:

(1') Engineering and design frameworks:

*Model-building was part of two cultures of artificial construction, of organized arrangement of connected parts: engineering and the arts.

*Machines became valued sources of models of natural phenomena.

(2') Philosophical and theological frameworks:

*Metaphysics was considered a source of fundamental ideas in physics; including the very idea of unity and generality as marks of knowledge proper since Plato and Aristotle, and the idea of necessity, hence the value of mathematics as source of necessity in reasoning and truth on empirical matters (unlike logic).

*Following Whewell's romantic view of the active unified and unifying mind and will, specific fundamental ideas –and terms- and principles organized specific theories and disciplines.

*Theological framework including metaphysical notions and natural theology consistent with the engineering framework by design. The foundation of scientific epistemology is warranted by the elimination of any fundamental distinction between natural and artificial, human and divine designs.

*Laws of nature are 'that portion of the Divine Order which relates to things without life,'[17] and 'are *not* mere arbitrary and unconnected decisions of Omnipotence, but that they are essential parts of one universal system in which infinite Power serves only to reveal unsearchable Wisdom and eternal Truth.'[18]

[15] Maxwell 1920 (M&M), art. 148, 122, my emphasis.
[16] Ibid., art. 149, 122, my emphasis.
[17] 'Inaugural Lecture', Aberdeen, 3 November 1856, Maxwell 1995 vol 1, 429.
[18] Ibid., 426.

Ultimately, our ideal knowledge is not of the form that things *are* so, but that they *must* be so or *ought to* be so, according to the connected necessity of the plan.[19]

*Natural theology: complexity design and simplicity of manufacture. God is the divine intelligent designer and manufacturer of identical atoms across the universe. Identity and invariance of ultimate atoms in the face of evolution and decay of macroscopic systems, biological (Darwin) and physical (Kelvin).

*Connected metaphysics of agency (power): human agency (mental and experimental), material agencies and divine agency. This view provides a sort of pre-established harmony between theoretical and experimental practice.[20]

4. On Epistemic and non-epistemic compromises: from moral and political philosophy to philosophy of science.

I suggest a direction of analysis that acknowledges the individual and social dimensions of scientific practice, cognitive, moral and political; and it borrows, accordingly, notions from moral and political philosophy (different from discussions of distributive cognition in social epistemology such as those by Solomon, Kitcher or Nersessian, or the more formal, game-theoretical framework in social and political theory).[21] Science and its understanding, as well as its guidance, rests on interpretive approaches familiar in the human sciences and the humanities. In the human sciences, especially the social sciences, the epistemic and non-epistemic (moral, political) are inseparable. The same must be the case of the more natural or harder sciences as human practice and therefore of their better study.

In this paper I focus on a recent proposal by Avishai Margalit in *On Compromises and Rotten Compromises*.[22] Written from the tension and violence of the Israeli-Palestinian conflict, Margalit's book is concerned with the conflict between peace and justice, which he finds at the heart of political thought, and with

[19] Ibid., 430.
[20] Cat forthcoming.
[21] Solomon 2001, Kitcher 2001, Nersessian 2008.
[22] Margalit 2010.

'what compromises we are allowed to make for the sake of peace', for the sake of a justified peace, not just peace.[23]

Margalit notes that 'removing compromise from moral theory is like removing friction from physics, claiming it belongs to engineering.'[24] I want to turn the analogy on its head and focus on the impossibility of removing friction and compromise from the practice of physics and the other sciences, and its value for justified developments in science, and, hence, also for the study of science, including philosophy of science. No removing friction from physics, then, and no removing compromises form philosophy of science. Indeed the removal of friction from physics is an instance of defining compromise in science.

Compromises can be warranted and warranting. They form the anticipated precondition of valuable projects and the unexpected condition of its development. The nature of science, however, requires that the idea of warranted compromise extend to epistemic as well as non-epistemic compromises. For instance, the discussions of unity and pluralism, reduction and reductionism, boundaries and cooperation form a case in point. Pluralism and disunity has often been rooted in conflict. Compromises pave often the sole way from conflict to cooperation. But conflict, I claim, can be either epistemic or non-epistemic, or inseparably both. I suggest that understanding compromises, epistemic and non-epistemic, provides useful understanding of a link between unavoidable conflict and valuable cooperation.

5. From conflict to compromise; from moral and political thought to philosophy of science.

Margalit develops his arguments subtly and, not surprisingly, formulates his intentions sharply. They aim at establishing a moral and political cast of mind that is willing to make compromises and also a line that should not be crossed: 'the book enunciates a firm admonition against making rotten compromises. It also sends a

[23] Ibid., 1.
[24] Ibid., 6.

word of warning against a bloody-minded uncompromising cast of mind –the mind of the sectarian.'[25]

Historical and philosophical examinations suggest that similar considerations may apply in the issue of reduction: reductions as rotten compromises and reductionism and anti-reductionism as uncompromising sectarian practices. Cooperation may be called for but it requires compromises, in practice and theory, and philosophy.

Margalit follows a number of moral and political philosophers in taking conflict seriously. They are clearly not alien to considerations of science. But their discussions of conflict seem to have incorporated the case of science merely as a contrast class or, for Margalit, a source of analogy and intellectual authority.[26] This will provide my point of departure for a more adequate connection and extension. To set up the broader framework for the problem and its solution, Margalit takes intellectual inspiration and guidance from three thinkers, Albert Einstein, Isaiah Berlin and Stuart Hampshire (see figure below).[27]

Berlin argued that, despite the Enlightenment ideal of harmony of universal values, human reality is irreducibly diverse; this diversity is best expressed by the persistent clashes of values.[28] Historical development and political life are inseparable without the former reducing away the latter, but rather the opposite, grounding its possibility and value.

According to Stuart Hampshire, history provides the occasion and evidence. As the French Revolution was the most important source of evidence in moral and political philosophy for Hegel, Marx, Mill and Tocqueville, the Russian Revolution and the ascendancy of National Socialism are the most important sources in our time.[29]

---

[25] Ibid., 14.
[26] Hampshire 1959.
[27] In Margalit's project it matters that these thinkers carry intellectual authority and they were either Jewish (the first two) or involved in defining episodes of Jewish history (the last). To me what matters is that scientists and philosophers are referred together on this issue of conflict and compromise.
[28] Berlin 1969, 169 and 172.
[29] Hampshire 1991.

As for the solution to the dilemma presented by conflicts, Margalit turns to Einstein's advice: 'Beware of rotten compromises'.[30]

Margalit's conclusion to the historical and moral-political conundrum is simply this: Churchill's agreement with Stalin against Hitler was a necessary compromise but not a rotten compromise.

To set up the proper extension to the case of science, first I should examine discussions of the centrality of conflict in moral and political thought in some more detail.

[30] Reported by Robert Schulmann, Margalit 2010, 199 n. 1.

Berlin and Hampshire have placed the idea of inevitable conflict in the human realms of morality and politics, in contrast with science, which they viewed as ruled by harmonious universality and objectivity.[31] For Berlin the persistence of conflict underpins the notion in political thought that human political freedom of choice is an end in itself, objectively valuable, while moral and political convictions are fallible and revisable. Hampshire has argued about morality that itself has its sources in conflicts. Moreover, it is concerned with regulating and adjudicating moral conflicts, not the search for 'an underlying harmony and unity behind the facts of moral experience.'[32] Michael Walzer's pluralist theory of political justice equally relies on conflict and incommensurability between different spheres of life goods.[33]

More recently, David Runciman has focused on the place in the pre-liberalist, anti-liberalist but especially liberalist traditions of political philosophy, of the conflict and compromise of double standards, e.g., hypocrisy.[34] From a historical perspective, he argues, hypocrisy is unavoidable in many forms which are, as a consequence, not worth worrying about, and may be also desirable in a democratic setting in others which are, therefore, worth encouraging. The role for political philosophy consists in distinguishing between kinds of hypocrisy and deciding which are worth worrying about.[35] And Runciman draws the line at destructive second-order hypocrisy: 'There is a big difference between those who do not live up to the standards they ask of others, and those who make a parade of their own ability to set an example.' The latter, second-order hypocrisy, 'because it makes a mockery of the whole business of public enactment, is corrosive in ways that first-order hypocrisy is not.'[36] And 'when hypocrisy deprives us of our ability to see what is at stake in our political life, then it still has the capacity to ruin everything for everyone…'[37]

---

[31] Berlin 1969 and 1991; Hampshire 1983; Hampshire 1991, and 2000.
[32] Hampshire 1983, 151-2.
[33] Walzer 1983.
[34] Runciman 2008.
[35] Runciman 2008, 225-26.
[36] Ibid., 224.
[37] Ibid., 226.

Theories of practical reason and rational choice have followed from the Aristotelian-Kantian canon in practical philosophy and also the related Austrian tradition in economics; for instance, Otto Neurath's political economy and scientific epistemology. These theories have turned to a more general and abstract discussion: of incommensurability of values (equality or liberty) and incomparability of their respective particular bearers or instances (particular policies, institutions, etc that have an effect on the expression of these values).[38] How is a justified choice possible? How is the consideration of values rational? The problematic and concepts engaged in this literature partly overlap with the discussion of incommensurability between theoretical meanings, and between competing or succeeding theories and paradigms defended by Feyerabend and Kuhn in the 1970s (contra Hsieh 2009).

In the abstract sense, incomparability is the relation that obtains between particular bearers of value when no positive comparative judgment is true; whereas incommensurability is a sort of relation between values that denies value monism or fundamentalism. For instance, strong incommensurability is the notion that there is no absolute ranking for the realization of all conflicting values in terms of a common value. Weak incommensurability denies that there is any value that ranks the realizations of any conflicting values. A third notion is the so-called tragic choice, which assumes that the gain in one value cannot cancel the loss in another.[39] Incommensurability may be considered constitutive of goods, although only because we are considering incomparable goods. Equally, it may be considered relative to social conventions. Moral dilemmas are not always instances of conflicts involving incommensurable values. Incommensurable values allow for justified choices in terms of the criterion of maximization, namely, that the choice is for an option that is not worse than the others. But they fail to be justified by optimization criteria such as the requirement that the chosen option be as good as the others.[40]

[38] Raz 1986; Richardson 1994; Chang 1997; Cat 2010; Hsieh 2009.
[39] Richardson 1994.
[40] Hsieh 2007.

Beyond the internal resources of the cognitivist models for evaluating value conflicts lie the external resources of constitutive goods, order of life goods, social institutions and morality. Transferred to the external worlds, incommensurability becomes an image of cultural diversity among incompatible ways of life, typically referred to as pluralism, liberalism, etc. Here the political, moral and the scientific problematics regarding conflict are on a par.

The last discussion along the same lines I want to introduce is also by way of contrast and connection with the much needed discussion regarding science. Michelle Moody-Adams has gone beyond Berlin and Hampshire's historicism to adopt a more empirical and theoretically detailed outlook on moral communities, or cultures.[41] Cultures are the entities that develop and impose on individuals patterns of socially developed normative expectations on emotion, thought and action.[42] Ethnographic data on cultural organic integration and cultural diversity suggests also that moral disagreement and conflict are fundamental, not resolvable by reasoning and argument. Her position, however, is that they are quite compatible with objectivity and transcultural nature of morality and moral inquiry, which she understands not as capacities or projects and procedures, as Berlin and Hampshire have done, but inquiry, values, principles and practices. No formalism and absolutism either. No "moral isolationism", Mary Midgley's term, with exclusive or impenetrable boundaries: 'serious moral disagreements –if they are genuine moral disagreements- will always be disagreements in the secondary "details" of morality, not in ultimate or fundamental principles and beliefs.'[43]

She defends the objectivity against positions of skepticism, emotivism and relativism that she sees wrongly inferred from conflict and incommensurability of values and principles. Her arguments simply hold fixed the opposite end of the stick, what she simply assumes to be general facts about cultures and holds to be their proper aims. Relativism and historicism assume cultural individuation, self-

[41] Moody-Adams 1997.
[42] Ibid., 225, n.2.
[43] Ibid., 16.

contained organic integration and determination of individual moral agency. As a result, relativism and historicism fail to ensure respect for unfamiliar practices.[44]

Her arguments come in the wake of Davidson's rejection of conceptual schemes and failures of interpretation due to incommensurability. Moral disagreement and the interpretation of unfamiliar practices are possible and describable only where there is quite substantial agreement about many of the basic concepts that are relevant to moral reflection.[45] Yet, her solution to the problem of objectivity, universality is rooted in the detailed, rich empirical description and interpretation rather than abstract detached speculation of moral theory. The possibility of comparability and agreement stems from the internal complexity, rather than organic integration, of cultures.

"Internal outsiders" exist at the margins of societies, in a "liminal cultural space", providing possibilities for internal cultural survival over time. This survival depends, in turn, on the capacity for self-evaluation and self-correction to criticize, revise and change. Internal conflict becomes the basis for cross-cultural understanding as well as moral argument and criticism. In anthropological models of science, Galison's linguistic and economic model of trading zones is the closest to the resulting space and stance of encounter and understanding of differences that results from each culture's liminal spaces.[46]

Self-scrutiny and revisability of self-conception, not organic self-contained cultural determination, is then the basis of moral inquiry, moral reflection and reform in practice. On this basis, Moody-Adams distinguishes difference from critical multiculturalism, which she endorses. Critical multiculturalism doesn't suppress internal conflicts that open the possibility of new cultural identities.[47]

She embraces a cognitivist approach in which morality and the role of conflict stand in contrast with much of science. Conflict is for her an expression of the properly understood rationality and objectivity of moral argument and

[44] Ibid., 62.
[45] Ibid., 55.
[46] Galison 1997.
[47] Ibid., 219.

inquiry.[48] Reasons run out, even in science. What can rationality and objectivity be in order to get the conclusions she seeks? Objectivity, she claims, expresses an aspiration to un-coerced agreement in the form of a transcendent validity of the outcomes of limited inquiry and does not imply uniqueness.[49] Rationality is expressed in agreements to disagree.[50] Conflicts are not problems to be solved with discrete, fixed solutions, after scientific cases, but disputes to be adjudicated, after the procedural legal model.[51]

And here she departs from Berlin and Hampshire. Participants make up explicit fundamental principles, rules or constraints. Explicit principles and rules are formulated, established and enforced in most cultures.[52] And generalities and particularities, abstraction and concreteness are well coordinated. She follows Walzer (and to some extent Bernard Williams and the anthropologist Clifford Geertz) in the philosophical assumption thick and thin concepts or representations are available and interchangeable: that a complexity of the thick interpretations of local, everyday structures of moral experience is available through interpretation and it can be always associated with the trans-cultural and trans-historical value of equally possible thin ones (contra detached abstract speculations of moral theorists).

Moral philosophy is thus an interpretive discipline: committed to the articulation and evaluation of unstated, and usually unreflective, moral convictions. It is best aligned with other interpretive disciplines such as history, ethnography and literary investigations of the moral imagination, and not with natural science.[53]

Moody-Adams account cannot automatically apply to science.[54] In the rest of the paper I will argue that despite the image of science opposed to moral life and its internal conflicts in accounts by Berlin, Hampshire, and Moody-Adams, science

[48] Ibid., 108.
[49] Ibid., 180 and 183.
[50] Ibid., 111; Cavell 1979, 254.
[51] Hampshire 1991 and 2000; Putnam 1990,181.
[52] Moody-Adams 1997, 165.
[53] Ibid., 222-23.
[54] Note that the equivalent of self-scrutiny and self-criticism in moral inquiry as sources of resistance and subsequent internal development of the moral community is dissent. For a model of dissent in science, see Solomon 2001.

equally benefits from conflict and science and philosophy of science benefit from interpretive approaches in the human sciences and philosophy to articulate the role of conflict in the possibility of development and cooperation. To go beyond Moody-Adams project, and to understand cooperation across boundaries in scientific life alongside moral and political life, and as part thereof, Margalit provides useful guidance.

6. From scientific conflicts to scientific compromises, epistemic and non-epistemic and mixed.

The study of science does not lack historiographical traditions of conflict- and incommensurability-centered accounts: Otto Neurath's incomparable pairs of theory and data, or incomparable or incompatible worldviews or social plans, requiring pragmatic decisions in order to make choices; the dynamics of some sort of dialectical view of history, with Kuhn's crisis and his and Feyerabend's meaning-incommensurable paradigms and theories; disciplines such as psychology's own crisis-centered narratives;[55] or the scientific debates rationally unresolved and settled through non-rational, external, political forms of closure, under the rubric, for instance, that 'solutions to the problem of knowledge are solutions to the problem of social order.'[56]

Conflict is a fact of scientific life; more so than the trope of crisis: from conflicts of interests, and political and moral conflicts to dissent, conflicting data, hypotheses or standards and values. To differentiate the extension of my account from the previous discussed above, but also a necessary connection, I distinguish between epistemic and non-epistemic conflicts. They form the context for the subsequent distinction between epistemic and non-epistemic compromises. On a first approximation, epistemic conflicts involve so-called epistemic values, assumptions, etc, i.e., those categorized as such. They are thought to be jointly

[55] Cat 2009 and Hylman and Sturm 2009.
[56] Shapin and Schaffer 1985, 332.

unacceptable or inapplicable. By contrast, non-epistemic ones are illustrated in the accounts above, with considerations from moral dilemmas, etc.

The distinction is useful insofar as, like a pair of fixed points or extreme values on a scale, it also points to the possibility of mixed cases.[57] These, I suggest, appear to be of two kinds. In the first, which I will call a *mixing conflict*, the conflict mixes constraints of epistemic and non-epistemic kind that are thought to be jointly unacceptable or inapplicable. A conflict of interest might be of this mixing kind; the ethical standards might conflict with cognitive or methodological standards or purposes, e.g., experimental methodology and the infliction of pain on subjects. The second type of mixed conflict, which I will call *ready-mixture conflict*, involves constraints, standards, values, assumptions, commitments, etc, that by themselves we think have a twofold source in epistemic and non-epistemic: natural and social sciences alike are inevitably fueled by valued categorizations and considerations that may or may not come to be perceived a biases (and ultimately resolved into mixing conflicts). The problem with this categorization is that, if pressed, we can identify many epistemic conflicts and non-epistemic conflicts, interestingly but quite generally, as of the ready-mixture kind. Both kinds make clear that science is neither conflict-free nor has conflicts of its own kind. As a human practice, it is rooted, empowered as well as constrained, by all aspects of human life. The distinctions and their failures will make it easier to motivate and extend my choice of Margalit's particular account of compromises.

Conflict is an expression of agency and creativity, but also fallibility and revisability.[58] From this standpoint, we find Neurath arguing in scientific epistemology as Berlin has in political philosophy and Hampshire in moral philosophy). It is one basis for plurality and pluralism and the difference that it expresses is one of the Millian sources for a social and critical sort of objectivity - defended by Feyerabend, Longino and others-, and also of productive interaction,

[57] I want to thank Melinda Fagan for pressing me in this direction.
[58] Conceptual conflicts are part of model-building successful strategies, in which a classic standard of logical rationality is traded for other methodological values of empirical adequacy, productive power, etc. See Cat 2005 for the examples from materials science (fracture dynamics) and Cat 2001 for the example of Maxwell's models of electromagnetism.

not isolation. I'm interested in a type of context for conflicts and dilemmas that is typically neglected in abstract speculation of rational choice or practical reason, political and moral theory, even more empirical accounts in social epistemology based on the idea of internal dissent and distributive cognition.[59] I will focus on a context in which conflicts are required for cooperation and interaction. In such contexts they form the basis for a creative form of cooperation that requires attention to compromises. Compromise is the missing link between conflict and cooperation. Compromises might involve a single individual or a group trying to synthesize elements from projects with different disciplinary or other commitments.

A compromise-based framework for scientific research can accommodate, besides the resolution of moral and political conflicts, cognitive or methodological attitudes and commitments that scientists take for granted, for instance, the rejection of absolute precision and completeness and the interest, instead, in the values of idealization and approximation in modeling and computational techniques.

7. Compromises vs. rotten compromises

Margalit offers the following characterization: a *compromise* is a decision or agreement that acknowledges a sacrifice relative to an ideal; a *rotten compromise* is a compromise that violates a fundamental value, e.g., the very possibility of shared humanity as the condition of possibility of morality: Alliance with Hitler's Nazism.[60]

Promising scientific research, I have noted at the beginning of this paper, seems to involve synthetic strategies of sharing resources across boundaries. Negotiating the terms of the cooperation requires identifying or anticipating possible conflicts and compromises. In the rest of the paper I will follow Margalit's proposal regarding non-epistemic compromises pretty systematically to suggest a corresponding extension for the mixed epistemic and non-epistemic life of science.

[59] Solomon 2001.
[60] Margalit 2010.

The distinction between compromises and rotten compromises in science is best suggested in terms of the distinctive epistemic dimension of science (I am leaving aside the non-epistemic dimension of applied science and engineering). An *epistemic compromise* would be a decision or agreement that acknowledged a sacrifice relative to an epistemic ideal in science. An example of this kind would be the acceptance or practical application of an economic model, say, that sacrifices predictive to explanatory power. A *non-epistemic compromise* in science would be a decision and agreement that acknowledged a sacrifice relative to a non-epistemic scientific ideal. For instance, making a compromise on research funding allocations relative to ethical or legal standards.

A rotten epistemic compromise would be a compromise that violates a fundamental epistemic value. Incommensurability requires the ultimate compromise without conflict. But interaction and decision-making are not monolithically -or holistically- and fundamentally based on incommensurable elements which reduce cooperation to coexistence and toleration, or compel forms of isolationism such as Midgley's moral isolationism, or else epistemic isolationism as described by Lynch and by Mitchell, stemming from normative pluralism and relativism.[61] An example of epistemic rotten compromise in science would be sacrificing the very possibility of shared knowledge, objectivity, measurement, etc as conditions of possibility of scientific practice. A *rotten non-epistemic compromise* in science would be compromise that violates a fundamental non-epistemic value in place in science, for instance, violations of ethical rules against plagiarism, say, or against participation in torture, adopted by a scientific professional body with legal consequences either only internal or also external.

Again, the two kinds, mixing and ready-mixture, of conflicts seems to suggest two additional mixed types of compromises.

[61] Lynch 1998; Cat 2007; Mitchell 2009.

8. Two pictures of politics and science.

Margalit offers two pictures of politics that help sort out the important differences regarding the adoption of compromises and the kinds adopted: *politics as economics* and *politics as religion*.[62]

Margalit characterizes *Politics as Economics* as follows:

PE1-The economic framework aims to allocate scarce resources to maximize utilities.

PE2-Everything is quantifiable and divisible.

PE3-Everything is qualitatively comparable and quantitatively commensurable.

PE4-Everything is exchangeable and has a price. Money is the ultimate exchange currency.

PE5-Everything that is divisible and exchangeable is subject to compromise. We can split the difference.

PE6-Everything is scarce and is subject to compromise.

PE7-Every compromise is a fly in the ointment compromise: it compromises merely a part.

Margalit offers, by contrast, the following characterization of *Politics as Religion*:

PR1-The religious framework aims at providing and protecting a way of life and meaning to human life.

PR2- An indivisible entity: God, nation, people…

PR3-The indivisible entity is absolutely so and admits of no legitimate fractions: heretics, independentists,...

PR4-The sacred entity is incomparable.

PR5-Holy trade-off is taboo: no small amount of holy A should be exchanged for a largest amount of B.

PR6-The sacred is priceless and admits of no compromise.

[62] Margalit 2020, ch. 1.

PR7-Any compromise is rotten compromise: a cockroach in the soup compromise: it compromises the whole.

By parity of reasoning, we may add to the corresponding extension of Margalit's pictures of politics to science, qua political and part of the political, two corresponding non-political pictures of science: science as economics and science as religion. The analogy or the corresponding extension of the framework should not be based on Margalit's specific images of religion and economics, or even that distinction itself, as long as some contrast can be established that explains and articulates the different compromises at work and their role.[63]

One may offer the following picture of *science as economics*:

SE1-Science aims to the efficient allocation of scarce resources such as and credit.[64]

SE2-Every concept is formalizable in mathematical terms.

SE3-Every entity is divisible.

SE4-Every description, no matter how complex, is reducible and replaceable

SE5-Economics can imitate physics or biology reduced to genetics if it supposes (allegedly) any epistemic and non-epistemic benefits.

SE6-Any concept, methodological idea, tool, skill, institutional model or practice etc may be dropped and replaced with one adopted from another science.

SE7-Compromises on one issue or modeling of one phenomenon are separable and do not have to affect another case.

One may similarly offer a picture of science as religion:

SR1-Indivisible, irreducible entities or properties: organism or emergent complexity of scientific organization and the entities it studies.

SR2-Meaning of theoretical terms is holistic.

SR3-No legitimate fractions, concepts or programs: no psychology in economics; no adaptationism or genetics in evolutionary and developmental

[63] I thank Keith Ward and Russell Manning to press me on this point.
[64] See, for instance, Kitcher 2001.

explanations; no quantum physics in material sciences; no quantum field theory in thermodynamics, etc.

SR4-The value of anti-reductionism and isolationism is non-negotiable.

SR5-Similarly for reductionism (fundamentalist and imperialist): only certain fundamental entities or concepts are acceptable indivisible units of analysis and explanation: rational agents, strings, genes, etc.

SR6-Reductionism and theories of everything are non-negotiable ambitions.

Margalit includes a discussion of what he calls the religious politics of land annexation. It involves typically two non-compromising forms of historical justification against peace. The first is, we were here first; the land belongs to us. The second is, we deserve it; it means everything to us.[65]

Religious politics of scientific annexation are illustrated not by reductionist projects, as forms of vertical integration. But horizontal expansion to new domains of explanation are, not to abuse the metaphor, just as relevant instances. The mechanical philosophy in 19th century physics aimed at integral and vertical integration of both heat and electromagnetic phenomena. For that purpose it marshaled field (continuum) and molecular mechanics based on earlier, more intelligible concepts.

9. Anemic vs. Sanguine compromises

The economic picture of politics has lent itself to the classical formalist game-theoretic modeling approaches to rational choice and decision-making from the second half of the 20th century in the Central-European tradition. Margalit identifies within this framework compromises he calls anemic that he distinguishes from others he calls sanguine.[66]

An *anemic compromise* is the outcome of a process ruled by a bargaining strategy; it is an agreement within the bargaining range of what something is worth

[65] Ibid., ch. 3.
[66] Ibid., ch. 2.

each party. By contrast, a *sanguine compromise* is an anemic compromise with recognition of a point of view of the other party.

Cooperation requires negotiation. But negotiation requires sanguine compromises. Margalit draws a further distinction. A sanguine *compromise in the negotiation* involves acknowledging that increasing one party's share requires increasing the other party's, narrowing down the rivalry with compromises on both sides. Whereas a more radical, higher-level, sanguine *compromise on the framework* of negotiation involves acknowledging the other party as rival over the same issue or resources rather than enemy to coerce or destroy. Sanguine compromises on the framework of negotiation involve giving up on a *dream* as constitutive element in the identity of a historical community.

Does the development of science illustrate compromises of these kinds in processes from conflict to cooperation? What are the equivalent analytical distinctions?

Anemic epistemic and non-epistemic compromises in science are agreements within the bargaining range of what some epistemic or non-epistemic process or outcome in science is worth each party. The abstract form of an example is the division of cognitive labor within a domain of description, explanation, prediction, etc.

Sanguine epistemic and non-epistemic compromises are anemic epistemic or non-epistemic compromises in science with recognition of a point of view of the other party and a common framework. For instance, acknowledging limits in modeling power while acknowledging the mathematical continuity-based modeling of classical electromagnetism by quantum mechanics in semiclassical models; or the dynamical framework acknowledged by evolutionary and developmental models in integrated evo-devo.

Sanguine compromise on the framework of negotiation involves giving up on a *dream* as constitutive element in the identity of a historical scientific community. This points to the difference between reduction and reductionism. Reductionism (dreams of a final theory) and antireductionism as forms of unification were subject of heated debates in the 1970s and 1980s among sub-communities of physicists,

between Steven Weinberg and Philip Anderson.[67] Condensed-matter physics has evolved to drop radical anti-reductionistic ideals in order to benefit from quantum-field-theory techniques. Other modes of cooperation have taken place between economists and psychologists, biologists and sociologists, geneticists and ecologists, etc.

The case of sanguine compromises raises the specter of the final or rotten compromise: What dream or constitutive ideal cannot be compromised? Margalit's answer in non-epistemic political and moral philosophy is this: crimes against humanity (and lasting peace) as the possibility of morality. What would then count as rotten epistemic and non-epistemic compromises in science? As I have indicated above, one may consider failures of transparency and objectivity. Also, defining individual and group scientific life was the case of the Manhattan project and its aftermath, with Oppenheimer's (mixing) conflicts over the construction of atomic and hydrogen bombs in contrast with Edward Teller's lack of them.[68]

10. Justification vs. duty

Compromises are occasions for reflective examination of commitments, tools for critical self-scrutiny in the face of research project development and project cooperation; the role in the context of projects will typically involve anticipation and resolution of conflicts. Margalit explores the normative force of commitments through the lens of a distinction between justification and duty. Recall that confronted historically and intellectually with a proverbial conflict between peace and justice, he aims at articulating a path to justified peace, not just peace.

Justification (of war) does not mean duty or obligation. Justification implies permission before the fact and excuse for forgiveness and understanding after the

[67] Cat 1998.

[68] Galison and Bernstein 1989.

fact. *Duty* requires, by contrast, necessity before the fact. Necessity requires the absence of alternatives; expedience does not and it is self-serving.[69]

There is room in science for epistemic and non-epistemic justification in this sense. Scientific justification implies epistemic permission for trial and epistemic excuse and understanding of error. Think again of reduction and other forms of connection in contrast with reductionism. Reductions may be justified but are hardly necessary in principle or practice. Similarly, for commitments to causal modeling as an explanatory or predictive commitment. This is the world of heuristics, with application warranted by permission and failure excused after the fact.

Talk of duty can only come in within the context of a more fundamental prior commitment that establishes the range of possibilities in such a manner that a course of action is singled out as necessary. It is relative. Reductionism is duty-based. In the context of project cooperation, it establishes what counts as a rotten compromise. Non-epistemic commitments may provide the duty that constrains the space of options, for instance in stem-cell research.

What sorts of communities are formed through allegiance to commitments? Margalit distinguishes between moral and non-moral societies, and between normative and prescriptive policies.

Non-moral societies may be composed of morally indifferent or immoral agents. They are guided by *prescriptive* policies. These include compromises. *Moral* societies, by contrast, are composed of agents motivated to bring about and maintain a morally just society. They are driven by *normative* policies or visions. Some compromises are rotten or unacceptable.[70]

Epistemic and non-epistemic scientific groups or arrangements of the moral and non-moral kinds may be said to exist or be possible. They are respectively ruled by normative and prescriptive scientific policies. An example of epistemic prescriptive cooperation is justified heuristics, tinkering in experimental situations. French molecular hypothesis and British field models in 19th century physics

[69] Ibid., ch. 4.
[70] Ibid., ch. 5.

illustrate the distinction between approaches that were hardly dogmatic and systematic in their acceptance and application.

By contrast, causal modeling practices and communities may instantiate a causal vision of the world and a causal standard. Other normative visions are either more specific, such as systems biology and its avoidance of reliance on the description of specific pathways mechanisms, or the conceptual and methodological commitments associated with the Chicago School of economics; or non-epistemic, such as the ethical and political constraints on stem-cell research.[71]

The distinction mirrors Margalit's subsequent distinction between expressive and effective politics. *Expressive politics* is based on the instantiation of an ideal; rotten compromises matter. *Effective politics* is based on the pursuit of a specific outcome. *Expressive scientific practice* instantiates an epistemic or non-epistemic ideal. It is normative and of the moral type, bound by duty and standards of rotten compromises. For instance, non-reductive models in biology may instantiate an anti-reductionistic attitude and will not compromise their rejection of the reference to genetic explanations. Similar considerations apply to gene-based reductionism. More abstractly, commitments to different methods of evidence in medicine or economics provide examples. *Effective scientific practice* pursues a specific outcome. Hybrid integrative models in engineering or biology or political science aiming at describing, explaining or predicting a specific phenomenon rather than express the full extent of a commitment to an ideal. Integrate approaches such as the so-called multi-method research are finally being urged from different corners of political science.[72] Epidemiological models, qualitative cultural models and formal game-theoretic and quantitative statistical political science, have joined resources to model the persistence and proliferation of diseases such as AIDS in Africa. Rich empirical case studies and formal game-theoretical models correct and strength each other in the study of the role of natural resources in the dynamics of political regimes. Corrections involve compromises relative to commitments.

[71] I thank Melinda Fagan for these examples.
[72] Brady and Collier 2004; Dunning 2009. I thank Matthew Gichohi for helpful discussions and sources.

Similar integrative approaches can be found in climate change research. Compromises are key. Fewer rotten compromises are at play.

Margalit speaks of sectarian and sectorial attitudes and groups involving totality of doctrines or ways of life. *Sectarian* politics and groups exploit indivisible differences (narcissism of minor differences) to refuse compromises on non-sacred things. *Sectorial* politics and groups are willing to negotiate a shared framework for their holistic doctrines in order to win followers.

In science, *sectarian* epistemic and non-epistemic scientific practices and groups are equally identifiable. Adaptationism in evolutionary biology involves the non-negotiable application of adaptive value to the explanation of survival of certain individuated traits of organisms.[73] The Chicago School of economics and free-market fundamentalism in general are examples too. *Sectorial* epistemic and non-epistemic scientific practices and groups include integrative projects such as evo-devo or the hybrid examples of effective science, above.

11.Compromises as necessary or desired second-best values

Scientific development and the scientific image need not be held hostage to either reductionism or isolationism. Local cooperation across boundaries on experimental and theoretical matters is often a venue of creativity in advancement towards a valued aim. But cooperation, a synthetic project involving a group or a single individually borrowing resources from different domains, requires a critical awareness of conflicts and willingness to make compromises.

The philosophy of critical compromise, moral, political and cognitive, eschews fundamentalism and absolutism in several forms: in the forms of global horizontal integration over the same level of phenomena and systems on a given hierarchy and classification, fundamentalism in the form of vertical integration local and global across levels, and local fundamentalism in the form of isolationism in the form identified by Midgley, Moody-Adams and Margalit, as sectarianism, in morality and political thought, and by Lynch and Mitchell in epistemology. These forms value

[73] Lewontin 1991.

uncompromising reaches for completeness, maximization and perfection. Another strand involves the rejection of rotten compromises that undermine the very possibility of morality.

By contrast, the spirit of compromise values compromises and rotten compromises. It is a philosophy of second-best choices, optimization over maximization, approximation over idealized exactness and perfection.[74]

Compromises in science are necessary or desired second-best values or standards, epistemic and non-epistemic. As a result, the synthesis of models and cooperation between members of different scientific communities is a source of innovation and scientific success. Awareness and willingness concerning the compromises makes the participant and the their institutions more critically reflective of the values and assumptions at stake and the standards at work. It is at the very least an effective tool for self-scrutiny and self-criticism. The outcome of that scrutiny should be the realization that no model, no group, project or disciplinary is ultimately self-sufficient and is about to exhaust its own resources in the pursuit of its own goals. Coordination across boundary lines is on order.

The philosophy of compromise is a broad framework that not only captures elements from moral, political and epistemic spheres of life, including scientific life, separately and in interaction. It also captures perspectives central to practice. Before the possibility of conflict and compromise arises in the synthesis of models, Spirit of scientific compromise values second-best choices, optimization over maximization, approximation over idealized exactness and perfection relative to real systems and theoretical models. Modeling involves a surrendering of the ideal of completeness and exactness of representation for the sake of other values. Scientific modeling as a synthesis, a construction, is based on conceptual analysis and idealization. Modeling shares with computational techniques also a commitment to the value of approximations. These practices are based on bottom lines about unacceptable rotten compromises and, above that line, key compromises. Compromises express both the fallibility and the effectiveness of

[74] Margalit 2010, 117.

science. In each case it is important to know what is the compromise involved and acknowledge the value of compromise.

Scientific projects, groups, disciplines will reject rotten compromises that undermine the very possibility of science. Each scientific community has scientific needs to consider in each context what constitutes its disciplinary conditions of survival and development. Conflict may provide, in Kuhn's words, essential tension, and be the source that facilitates continuing practice. Inconsistency itself is for instance the outcome of compromise.[75] But conflict may be an obstacle for science rather than an organ of science. Compromises provide a link to explore in the path from conflict to cooperation. Debates over evolution in opposition to intelligent design, and over the relation between science and religion call for the characterization of rotten compromises in science.

Compromises in the face of conflict or the impossibility to achieve completeness and totality may be the only way forward in the construction or synthesis of a model, the coordination and development of a project, and the coordination of cooperation across boundaries that separate practices. The relative autonomy of disciplines implies that multi-disciplinarity is a precondition of cooperation –local inter-disciplinarity- and development. This extends to the relation between science and philosophy. The critical philosophy of compromises outlines a guide that replaces reductionism as an ambition of scientific life and unity, and it also integrates moral and political dimensions of scientific life as part of human life.

Acknowledgments

This paper is based on a talk given at the Views on Reduction Workshop, Centre for the Philosophy of the Natural and Social Sciences, in London, 20 July 2010, as part of the 'Order of Nature' Project, Templeton Foundation. I thank Nancy Cartwright, Eleonora Montuschi and the other workshop organizers, and the audience for encouragement and stimulating questions.

[75] Cat 2005, Frisch 2005 and Meheus 2002.

References

Barberousse, A. and P. Ludwig 2009, 'Models as Fictions', in M. Suarez, ed., *Fictions in Science: philosophical essays on modeling and idealization*, New York: Routledge, 2009, 56-73.

Berlin, I., 1969, *Four Essays on Liberty*, Oxford: Oxford University Press.

Berlin, I., 1991, *The Crooked Timber of Humanity*, Princeton: Princeton University Press.

Brady, H.E., and D. Collier, *Rethinking Social Inquiry: Diverse Tools, Shared Standards*, Landham, MD: Rowmand and Littlefield.

Cartwright, N., J. Cat, K., Fleck and T., Uebel, 1996, *Otto Neurath: Philosophy Between Science and Politics*, Cambridge: Cambridge University Press.

Cat, J., 1995, 'The Popper-Neurath Debate and Neurath's Attack on Scientific Method'. *Stud. Hist. Phil. Sci.*, vol. 26, No. 2 (1995), pp. 219-250.

Cat, J., 1998, 'The Physicists' Debates on Unification in Physics at the End of the 20th Century', *Historical Studies in the Physical and Biological Sciences*, vol. 28. part 2: 253-300.

Cat, J., 2001, 'On Understanding: Maxwell on the Methods of Illustration and Scientific Metaphor', in *Stud. Hist. Phil. Mod. Phys*. Vol. 33B, n.3 (2001), pp. 395-442.

Cat, J., 2005, 'Modelling Cracks and Cracking Models: Structures, Mechanisms, Boundary Conditions, Constraints, Inconsistencies and the Proper Domains of Natural Laws', *Synthese* 146, n. 3 (2005), 41 pp 441-481.

Cat 2007, 'Scientific Unity', *Stanford Encyclopedia of Philosophy* online.

Cat, J., 2009, 'Crisis in Psychology and Philosophy: Disciplinary Crisis as an Interdisciplinary Situation', in L. Hylman and T. Sturm, eds, *Crisis in Psychology: Causes and Contexts*, Max Planck Institute, Berlin.

Cat, J., 2010, 'Otto Neurath', *Stanford Encyclopedia of Philosophy* online.

Cat, J., forthcoming, *Master and Designer of Fields. James Clerk Maxwell and Concrete,*

Constructive, Connective and Conventionalist Natural Philosophy, Oxford: Oxford University Press.

Cat. J. and T. Gennaro, forthcoming, 'Analysis of Theories and Synthesis of Models'.

Cavell, S., 1979, *The Claim of Reason*, New York: Oxford University Press.

Chang, R., 1997, *Incommensurability, Incomparability, and Practical Reason*, Cambridge, MA: Harvard University Press.

Dunning, T., 2009, *Crude Democracy: Natural Resource wealth and Political Regimes*, New York: Cambridge University Press.

Frisch, M., 2005, *Inconsistency, Asymmetry and non-Locality: A Philosophical Investigation of Classical Electrodynamics*, New York: Oxford University Press.

Galison, P., 1997, *Image and Logic: A Material Culture of Microphysics*, Chicago: University of Chicago Press.

Galison, P. and P. Bernstein 1989, 'In Any Light: Scientists and the Decision to Build the Superbomb, 1952-1954', *Historical Studies in the Physical and Biological Sciences* 19, No. 2 (1989), pp. 267-347.

Hampshire, S.N., 1959, *Thought and Action*, London: Chatto & Windus.

Hampshire, S.N., 1983, *Morality and Conflict*, Cambridge, MA: Harvard University Press.

Hampshire, S.N., 1991, *Innocence and Experience*, Cambridge, MA: Harvard University Press.

Hampshire, S.N., 2000, *Justice is Conflict*, Princeton: Princeton University Press.

Hsieh, N., 2007, 'Is Incomparability a Problem for Anyone?' *Economics and Philosophy*, 23: 65-80

Hsieh, N., 2009, 'Incommensurable Values', *Stanford Encyclopedia of Philosophy* online.

Hylman, L. and T. Sturm, eds, 2009, *Crisis in Psychology: Causes and Contexts*, Max Planck Institute, Berlin.

Kitcher, P., 2001, *Science, Truth and Democracy*, New York: Oxford University Press.

Lewontin. R.C., 1991, *Biology as ideology*. The Doctrine of DNA, Chicago: University of Chicago Press.

Lynch, M.P., 1998, *Truth in Context*, Cambridge, MA: MIT Press.

Margalit, A., 2010, *On Compromise and Rotten Compromise*, Princeton: Princeton University Press.

Maxwell, J.C., D. Niven, ed., 1890, *The Scientific Papers of James Clerk Maxwell*, Cambridge: Cambridge University Press.

Maxwell 1920, J. Larmor, ed., *Matter and Motion*, London: Society for the Promotion of Christian Knowledge.

Meheus, J., ed. 2002, , *Inconsistencies in Science*, Dordrecht; Kluwer.

Mitchell, S., 2009, *Unsimple Truths: Science, Complexity and Policy*, Chicago: University of Chicago Press.

Moody-Adams, M., 1997, *Fieldwork in Familiar Places: Morality, Culture and Philosophy*, Cambridge, MA: Harvard University Press.

Nersessian, N., 2008, *Creating Scientific Concepts*, Cambridge, MA: MIT Press.

Putnam, H., 1990, *Realism with a Human Face*, Cambridge, MA: Harvard University Press.

Raz, J., 1986, *The Morality of Freedom*, Oxford: Clarendon Press.

Richardson, H., 1994, *Practical Reasoning about Final Ends*, Cambridge: Cambridge University Press.

Runciman, D., 2008, *Political Hypocrisy*, Princeton: Princeton University Press.

Shapin, S. and S. Schaffer 1985, *Leviathan and the Air-pump. Hobbes, Boyle and the Experimental Life*, Princeton: Princeton University Press

Solomon, M., 2001, *Social Empiricis*m, Cambridge, MA: MIT Press.

Walzer, M., 1983, *Spheres of Justice*, New York: Basic Books.