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Encounters between Philosophy of Science, Philosophy of Technology and STS

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Introduction

1 In his article *An Unrequited Love. Social Sciences and STS,* Pablo Kreimer (2017) compares the relationship between STS (Science and Technology Studies) and the social sciences to an unrequited love. This analogy seems inadequate for understanding the as yet distant relationship between STS and the philosophy of science and technology. Between these different fields of science and technology studies there appears rather to be a relationship similar to the one existing among people belonging to different generations, contexts, or cultures, in which barriers, gaps, and prejudices must be overcome in order to achieve a fluid, fertile, and productive mode of interaction.

2 Indeed, since the 1970's, distance, controversies and disputes have dominated the relationship between philosophy of science and STS. Nevertheless, after the battles fought in the 90's in the context of the "science wars", a new scenario of encounters between the aforementioned fields has emerged, up till now limited to a few specific arenas and programs of study that, unfortunately, are not widely known. These nonetheless show the constructive possibilities of such interactions, especially when it comes to opening new paths for the analysis of science and technology. This thematic dossier is an invitation to further the development of constructive encounters between these fields, beyond old disputes, gaps, and preconceived prejudices.

3 Interactions between these two fields can be viewed from two starting points: from STS towards philosophy, or from philosophy towards STS. The distance between these fields has been greater from philosophy towards STS, since from the inception of their field, STS scholars have created a variety of approaches to and dialogues with philosophical traditions.[1] In this text we focus on the other direction, analyzing the connections established by some philosophers of science and technology with developments in STS, in order to show how some philosophical approaches and investigations, still ignored by most, have opened up rich interactions with STS and used them to build important, alternative conceptions of science and technology.

4 The extensive work of Anouk Barberousse (2018) and Joseph Rouse (2011) investigating the relations between philosophy and STS shows a general tendency in the philosophies of science and technology to stress the distance that arises between the theoretical frameworks and the methods of analysis that are proper to each field, rather than to facilitate a dialogue on the basis of shared interests and referents. Furthermore, according to Barberousse (2018, p. 262), the distance between the philosophy of science, the philosophy of technology, and STS seems to be extended in most philosophical approaches, rather than remaining static, diminishing or even dissolving.

5 Nonetheless, Rouse (2011, p. 2) clarifies that during the last two decades some constructive interactions, both interesting and relevant, have been developing between these fields regarding some specific topics, perspectives, and research programs. This thematic dossier is an invitation to reduce such distances and to establish encounters between the fields. The contributions presented in this dossier are examples of these encounters between philosophy and STS in relation to particular topics.

6 To widen the analysis of the relations established between STS and philosophy, in the present text we discuss: 1) According to the work of Rouse (2011) and Dominique Pestre (2004), during the last two decades, a new scenario of constructive interactions between the philosophy of science and technology and the STS field has emerged, after the passionate discrepancies staked out in the "science wars". These new interactions emerged not only out of the exhaustion of the controversies, but also in the light of a crisis concerning the reductive views of science and technology within both philosophy and STS, the identification of the limitations of these perspectives, and the acknowledgment of possible shared points of view. Taking into consideration that STS and the philosophy of science and technology both integrate multiple and opposing perspectives, we can construe the consequences of the disputes of the science wars had consequences as the following; they reaffirmed the distance between some perspectives, while smoothing out some differences and highlighting spaces for building new relations between other perspectives. 2) A significant number of the encounters of the last two decades between the aforementioned fields have been motivated, implicitly or explicitly, by a shared interest in alternative conceptions of science and technology.

7 In accordance with these developments, this text presents some encounters between STS and philosophy of science and technology through which especially meaningful shared perspectives have emerged. We focus on approaches and encounters that have generated processes of transdisciplinary knowledge between these fields.

8 From the philosophy of science, we highlight the following perspectives that have been especially favorable to encounters with STS: first, a philosophical turn towards towards

an analysis of the study of scientific experimentation and material culture in science, such as we see in the work of Ian Hacking, Peter Galison, etc.; second, a wide range of perspectives articulated on the basis of the current "practice turn" proposed within the philosophy of science; and third, and closely linked to the latter, a philosophical program that has consolidated around historical epistemology and the conceptual history of science, based on the work of thinkers such as Lorraine Daston, Jürgen Renn, and Hans-Jörg Reinberger.

9 From the philosophy of technology, we analyze the connections created between the "empiricist turn" in this field and STS. In the last decades, philosophers as Hans Achterhuis (2001) and Philip Brey (2010) have pointed out an important turn in philosophy of technology towards the concrete technological object and its agential, mediating role, in place of more traditional reflections focused on the criticism of technical culture, based on a general notion of technique. Out of this empiricist turn philosophers of technology have developed a rich dialogue with perspectives like actor-network theory, and new empirical and philosophical points of view, such as the post-phenomenology proposed by Don Ihde, Peter-Paul Verbeek, etc.

10 Before analyzing these perspectives, we present a synthesis of the history of the relations between these fields spanning the several decades after 1970. Then we explain in detail the changes in interests and scenarios of encounter between STS and philosophy beginning with the "science wars". In the final section we discuss some shared interests and points of view concerning science and technology that can be distilled from the perspectives we have highlighted. Finally, we include a brief overview of the contributions of each author of this thematic dossier.

Brief History of the Relations between the Fields

11 The history of the relations between philosophies of science and technology and STS can be traced back to the very origins of the field of STS in the 1970's. The details of the long history of encounters and divisions between these fields are beyond the scope of this article, but some important moments are worth reviewing here.

12 The debates between sociologists and philosophers started in the 70's, centering on the explanatory ambitions of the Sociology of Scientific Knowledge (SSK), which radicalized the social analyses of science proposed by Ludwik Fleck and Thomas Kuhn. Some sociologists, such as David Bloor, Barry Barnes and Harry Collins, working from the tenets of the strong programme, and, subsequently, the empirical programme of relativism, challenged both the rationalist explanations of philosophy of science and the weak epistemological ambitions of classical sociology of science. Continued confrontations between sociologists and philosophers kept the flames of the debate between rationalism and relativism alive, with a failed attempt to extinguish the fire by distinguishing between internalist and externalist views in the study of science.

13 In the 1980's, the heated discussions of the 70's moved to the back burner, with each field developing in its own path without much interaction between them. In STS the decade birthed important transformations like the emergence of laboratory studies, the formulation of constructivist approaches in science studies, later extended to the study of technology (in seminal text by Wiebe Bijker, Trevor Pinch, and Thomas Hughes (1987) and the development of the SCOT perspective), and the development of new methodological approaches distinct from the sociological perspective of SSK, through

the adoption of ethnography, ethnomethodology, the study of inscriptions, and the sociology of associations. These important transformations in STS did not receive much attention in philosophy of science and philosophy of technology circles, with the exceptions of the work of some philosophers of science like Ian Hacking, Peter Galison, Lorraine Daston, Anemarie Mol, etc., and the contributions of Andrew Feenberg and Don Ihde in the philosophy of technology. In both cases, the philosophical perspectives of these authors were nourished by the empirical approaches of STS, and in particular by the understanding of the practices and processes of material agency articulated by actor-network theory. However, scarce attention was paid to their work, and it remained marginal and even invisible both to other philosophers of science, who continued to concentrate their efforts on an analysis of the rational conditions of scientific theories, and to other philosophers of technology, who remained devoted articulating hermeneutical and phenomenological critiques of modern technological culture as a whole.

14 In the 1990's, the controversies and discrepancies between philosophy and STS reached their highest level of tension with the publication of a text by Paul R. Gross and Norman Levitt (1994), *Higher Superstition,* and with the Sokal scandal in 1996, which were the sparks that lit the blaze of the so-called "science wars"[2]. In this context the debates between those accusing each other of being rationalist or relativist, constructivist or realist, postmodern etc., were radicalized, significantly increasing the distance between the two fields. Despite a cooling of the initial heat of the disputes from the 1990's, in many ways this distance has continued to characterize the relations between them ever since. In the two decades that follow, and up to the present, the interactions between these fields remain few and far between, although new scenarios have emerged that have created a space for meaningful encounters between them, as we explain in what follows.

15 Part of the distancing and barriers between these fields can be explained by some concrete tendencies within philosophy of science and technology. Amongst philosophers of science and technology who remain wedded to certain aspects of scientism and positivism, it is common to hold prejudices and learned biases towards the social sciences and all analysis arising from them. They also continue to be entrenched in the study of scientific theories from aprioristic points of view, with extremely weak empirical content, downplaying and remaining ignorant of the importance of technology studies, and the broad and diverse studies of scientific practices and of the material and technical aspects of knowledge that they have generated.

16 The importance of adhering to traditional philosophical methods based in analysis and interpretation of theoretical perspectives and without recourse to empirical studies has made it difficult for philosophers of science to understand the typical methodologies of STS, which consist in framing, honing and building theoretical and conceptual problems precisely *through* interaction with case studies and other types of empirical analyses. The field of STS has grown extensively over the last forty years by using the specific contributions of case studies to heuristically approach theoretical and conceptual problems, question or strengthen existing concepts, or create new ones. The vast majority of the new concepts produced in this field, many of them formulated without recourse to any particular theory, has usually served to improve analyses of field work before contributing to the development of generalized theories. The

distances generated by this lack of understanding are reinforced by a common prejudice within STS according to which philosophy has little pertinence to and relevance for analyzing current and important problems in science and technology.

17 Thus we see that the barriers that prevent a greater dialogue between the two fields are related in part to misunderstandings that arise from the different research orientations traditionally assumed within each field, especially in terms of their distinct epistemological and methodological preferences and the greater or lesser importance attributed within each to the role of empirical analysis. But these differences mean that possible encounters between the two perspectives can be highly constructive for widening and enriching both perspectives.

Changes of Settings and Interests

18 As we have shown, the spaces of encounter between various perspectives on the study of science and technology has changed over the last three decades, opening up new ways to set the terms of the relationship beyond those proposed before and after the "science wars" of the 1990's.

19 In an arena previously dominated by criticisms, contrapositions, and epistemological and methodological discrepancies between philosophers of science and technology and STS theorists, new spaces have been created for shared interests, common perspectives, collaborative work and the development of contributions and frameworks in specialized fields still widely unknown.

20 In recent decades, approaches to the STS and to philosophy of science and technology have diversified widely within each field. The possibilities for interactions between the two fields have also diversified accordingly. This is why, in certain perspectives, echoes of the former debates of the "science wars" can still be heard, while in others we see a clear focus on collaborative work and transfers between theoretical and methodological frameworks. Some perspectives, such as those presented in this text, have even developed transdisciplinarily.

21 The early years of STS, up to 1985, continued to be characterized by clear opposition between orthodox epistemologists and sociologists of scientific knowledge.

> The first is that no agreement could emerge with orthodox epistemologists as the British proponents of SSK tried to show again and again that there was no 'natural necessity' behind scientific consensus (Nature does not alone underwrite scientific claims). Instead, SSK held that scientific propositions arose from particular, unique alchemies, from the conjunction of specific material, literary and social 'technologies.' (Pestre, 2004, p. 354)

22 As we have seen, these confrontations fueled the debates known as "science wars" during the 90's, and created a public stage for the continuous and wearisome mutual criticism between orthodox epistemologists and STS scholars. Most of the contributions of the sociologists of scientific knowledge were oriented toward a critique of the traditional and generalized understandings of both scientific knowledge and reality defended by philosophers and scientists.

23 Specifically, they confronted the scientism and metaphysical realism of the conception of science inherited from positivism, from a critical constructivist point of view, oriented towards acknowledging the limits of all reductivist approaches to knowledge and thus shaking, through an analysis of scientific controversies, a naive trust in

science as an activity capable of separating alleged "facts," or "pure" knowledge, from social and cultural processes of knowledge construction. Rather than dissolving facts, they portrayed the intrinsic complexity of human actions in scientific practices, using symmetrical studies of controversies, as a powerful tool for questioning science as an institution of power. They questioned the prescriptive sense of normative postures by adhering to the principle of symmetry: following actors equally, eliminating references to other frameworks of analysis, and suspending value judgements other than those invoked by the actors themselves (Pestre, 2004, pp. 354-356).

24 The central interest of sociologists as Bloor and Collins was to follow actors in their own contexts and observe what they do and state, in the manner of social scientists, rather than to build an epistemology and establish the relative weight of the social and natural in scientific statements. Nevertheless,

> One thing that is worth noting immediately, however, is that most (initial) partisans of SSK aimed to be scientific themselves (they wanted, in the terms of a well-known and significant expression, to describe science 'as it is really done') but they also wanted to act politically – denouncing science as an institution while revealing its 'true' nature. (Pestre, 2004, pp. 352)

25 The science wars were dominated by confrontations between a rationalist and representationalist philosophy of science, focused on the analysis of theories and oriented towards empirical justification, and a sociology, also representationalist, focused on the interpretation of the social conditions that created the basis for the adoption of a particular scientific explanation. The ambitious program of social science to formulate a critique of orthodox epistemology provided the main weapon wielded by the sociologists.

26 On the other hand, for most of the philosophers of science of that time, the constructivist perspective of SSK was popularized as a relativist, contextualist, social realist or social conventionalist point of view that furthered the ideals of a relativist counter-culture, and whose intent was a mere questioning of the *status quo.*

27 According to Rouse (2011, p. 11), apart from their public staging, these confrontations revealed some limitations of the dominant perspectives, both of the philosophy of science and of SSK, thus preparing the stage for some re-assessments. To support this point of view, Rouse (2011, p. 12) picks up the diagnosis made by authors like John Zammito (2004) concerning the state of the philosophy of science and STS in the context of the public controversies of the 90's, but questions their radical judgements according to which both fields wound up in a dead end, exhausted their points of view, or fragmented their approaches. In contrast, he considers that this context rather stimulated the emergence of new and interesting converging research programs, in both philosophy of science and STS. In these new perspectives, Rouse notes, a new image of science and the world arose, concerned with attention to scientific practices and the material culture of science. He affirms that, in both philosophy of science and recent perspectives in STS,

> the principal focus has instead been to understand discursive articulation as integral to material interaction within the world, rather than as independently meaningful representation. (Rouse, 2011, p. 22).

28 Pestre (2004, p. 356) also argues that the confrontations of the science wars laid the critical foundations for the development of other perspectives and the formulation of breaches within each field. Specifically, during the last three decades an important, possibly irreversible, breached occurred, in the studies of science and technology

which modified the scenario of relations with the philosophy of science (Pestre, 2004, p. 351). In contrast with the SSK program, ethnomethodological laboratory studies, such as that of from Bruno Latour and Steve Woolgar (1979), focused their attention on a primary level of analysis, or on the development of *in situ* scientific practices, instead of the analysis of content or the lasting meaning of the produced knowledge that were the focus in the study of the controversies. In general, they worked beyond the scope of the scientistic social criticism of the SSK, and its attempt to propose a social and structural causal structural explanation of scientific knowledge. In Pestre's words (2004),

> In this frame, the question is no longer to know how scientists' propositions become epistemologically true (the classic program of the history and philosophy of science) nor is it to figure out how legitimacy is negotiated within the scientific community (a possible definition for the 'controversy' program). Instead, the aim is to describe how claims come to impose themselves through the mobilization of objects and practices in the struggle for survival. Science is understood as a practice that produces and invents order rather than as a system that 'reveals' the hidden order of nature. (p. 357)

29 In general terms, the disputes that took place within the context of the science wars revealed important limitations both for philosophy of science, and STS, a field which was, up to that point, dominated by the SSK, and in both cases motivating a turn towards strengthening of other perspectives birthed in the 1980's, such as actor-network theory, or a philosophy of science focused on material practices in science. In this context certain points of view lost traction and others gained traction, particularly in STS, since philosophy of science was, and continues even today to be, rooted in a rationalist and representationalist understanding of science.

30 With the intention of increasing general knowledge of these new scenarios of interaction between philosophy of science, philosophy of technology, and STS, in what follows we present some recent research programs in philosophy of science and philosophy of technology, all of which share a common transdisciplinary focus in relation to the aforementioned study fields and within which emerge important transformations in conceptions of science and technology.

Philosophical Perspectives on Science and their interactions with STS

Studies on Scientific Experimentation in the Laboratory

31 The study of scientific experimentation, especially in the context of the laboratory, has probably been the most prolific area for the transformation of the conceptions of science, in both STS and philosophy. Studies of what happens in laboratories have been, in their own way, the laboratory itself where a partial vision of science understood only as concepts, theories, and representations has been transformed into a broader view of science as material activity.

32 After a long period during which experimentation played a subservient role to theory, or when it was only conceived as an empirical tool for testing theories, during the 80's a field of new study emerged, focused on the "life of its own" of experimental practice, as Hacking famously described it (1996, p. 149).

33 These kinds of studies were developed through the connections between contributions from historians, sociologists, anthropologists, and philosophers of science, and are an example of constructive transdisciplinary interactions around a single object of study.

34 Within philosophy, these various approaches to the study of laboratory experimentation were consolidated into a legitimate sub-discipline, as described by Hacking (1988), Diderik Batens & Jean-Paul van Bendegem (1988), and David Gooding *et al.* (1989). Initially, it was structured from the works of Hacking (1983)[3], Galison (1987), and J.S. Rigden & Roger Steuwer (Achinstein & Hannaway, 1985). Even though this sub-discipline was developed within a wider framework of various pioneer laboratory studies, many of them came out of STS, such as Latour & Woolgar (1979), Simon Shaffer & Steven Shapin (1985)[4], Andrew Pickering (1984), Michael Lynch (1985), Sharon Traweek, (1988), Karin Knorr Cetina (1981), Terry Shinn (1980, 1988), Bernard Feltz (1991), John Law & R. J. Williams (1982), and Dominique Vinck (1992).[5] In the work of Jerome R. Ravetz (1971), Georges Thill (1973), and Lemaine *et al* (1982) we see some early approaches that anticipated the development of this perspective. Ravetz considered that the quality of scientific research depended on experimental processes (Hacking, 1988, pp. 147-148) (Vinck, 2007). And Georges Thill was a pioneer and precursor of laboratory ethnography, before Latour and Knorr Cetina, with his analysis of an experiment in high energy physics (Vinck, 2007 y 2019).[6]

35 Some of the main contributions from this transdisciplinary field are the following:

- First, these studies showed the richness and diversity of experimental work, disarticulating a partial and monistic methodological vision of the experiment and laying the foundation for a pluralist view. In methodological terms, experiments are developed not only to demonstrate but also to explore and produce. They form part of programs of scientific research as well as technological and industrial projects.
- Second, these studies demonstrated the inherent value of experimentation work, within its own and relatively autonomous dynamics of experimentation. Nowadays, it is considered inadequate to talk merely of mere experimentation, as Sergio Sismondo (2010, p. 158) argues; it is more accurate to speak of "experimental life", "experimental work", and "experimental culture". These designations construe experimentation as a specialized activity involving routines, habits, discipline, skills, resources, infrastructure, etc. Experimentation, in this view, is usually oriented towards the achievement of its own specific goals, not reducible to an instance of, or a procedure in service of, other broader instances. The world of experimental researchers is often a singular world, with a specific language, with specific objectives, not necessarily striving to prove a theory but rather, for example, to produce an effect, or stabilize a phenomenon, or perfect some instrument or measurement, or widen the field of experience, etc. Experimental work includes an autonomous "know how" related to specific and specialized objectives. It also supposes a "practical load", in addition to the "theoretical load" mentioned by Norwood R. Hanson (1958).
- Third, these studies of experimentation, especially those produced in laboratories, reveal the rich material culture of science, overlooked by a philosophy of science dominated by the study of theories and, in general, of representational content. In the face of such a philosophy, laboratories have become privileged settings for the study of the material sense of scientific practices. This has enabled a broadening of the understanding of these practices proposed by the history and sociology of scientific knowledge, which since the 1960's had been focused on the analysis of beliefs, assumptions, contexts, interests, etc., invisibilized in

the conceptual and formal study of theories. In this context the notion of practices referred to past and forgotten circumstances and conceptions that could be clarified and reconstructed through archival study. In the philosophy of experimental work, however, the notion of practices has been extended to concrete activities like the use of instruments and processes of observation, measurement, calculation, generalization, etc.; it is no longer limited to representational content, but now includes material activities. In general terms, laboratory studies have produced a turn from historical practices, from the reconstruction of contexts and representations, to "effective", *in situ* practices, proper to "science in action" (Latour, 1987), and to the material culture of science, as framed by actor-network theory.

- Fourth, these studies of experimentation arose in the epicenter of important discussions about classical problems in science, such as objectivity, evidence, the building of facts, empirical adequacy, etc. An adequate understanding of the specific dynamics of the work of experimentation demanded the development of new concepts shared with STS, such as "self-vindication", "mutual accommodation", "stabilization", "agency", etc., that shed light on the partial and reductive sense of traditional concepts like "fact, "empirical adequacy", "theoretical justification", etc. The value of these concepts is not limited to an analysis of specific aspects of experimental work; they are also foundational to a thorough and complex understanding of the whole of scientific work in general. The study of the work of experimentation is thus a field that enriches current conceptual frameworks, analytical schemes, and language for understanding science in general.

The Practice Turn in Philosophy of Science

36 Since logical positivism, philosophy of science has devoted itself mainly to the study of scientific theories and processes of justification. Nonetheless, since the middle of the 20th century an orientation towards the study of scientific practices has gradually and progressively developed. This tendency was initially fostered by the pioneer work of Ludwing Fleck and Thomas Kuhn, among others, who built their philosophical points of view on the foundation of key contributions from the history and sociology of science. Ludwing Wittgenstein and a diverse group of philosophers argued for the relevance of the analysis of practice as a starting point for addressing knowledge problems. Nonetheless, the turn towards concrete practices was born and fundamentally configured in the empirical terrain of science studies, and particularly actor-network theory and studies on the *in situ* work of scientists.

37 From the actor-net theory, the study of inscriptions (rather than concepts and theories) and the adoption of an ethnomethodological approach laid the foundations for the analysis of scientific practices. These practices were addressed as concrete and material, using an analysis of the processes of conversion, aggregation, transformation, and circulation of inscriptions in a specific social and cultural context.

38 This kind of transformation in the studies of science motivated the development, within the philosophy of science, of a turn towards the philosophical study of science based on the analysis of practices (*practice turn*) proposed by Rouse (1996, 1999, 2002) and other philosophers. This proposal became a movement with the creation of the *Society for Philosophy of Science in Practice*[7] in 2007, and has grown in response to contributions from other authors such as Lena Soler *et al* (2014), Sergio Martínez & Xiang Huang (2015), and Sergio Martínez *et al.* (2008).

39 This movement has focused mainly on two elements. First, it has offered a critical arsenal for questioning the rooted idea in the philosophy of science that practices are irrelevant to explanations of scientific rationality, and for dismantling a limited understanding of practices as simple applications of theories or generators of evidence. Secondly, it has made some important contributions to the analysis of the role of practices in the normative structures of science.

40 Up to now, this movement has developed mainly in the analytic mode of thinking the theoretical implications of the effort to understand science on the basis of an analysis of practices, rather than in the empirical mode of studying the concrete forms of the practice of science and establishing their philosophical consequences.

41 In general terms, Rouse and other philosophers working within this perspective argue that scientific practices hold a normative sense, insofar as they are judged as right or wrong, independent of any regulative context. Working from the starting point of the normative understanding of practices offered by Wittgenstein and the analysis of implicit normative of practices proposed by the contemporary philosopher Robert Brandom (1994, 2000), Rouse affirms that the explicit scientific normativity of rules is built on a normativity implicit to practices. That is, broadening the analysis of normativity of practices in general towards a normativity of scientific practices, it is clear that these are not trivial elements for the normative analysis of science, but the domain where normativity itself is implicitly constituted and supported.

42 These philosophical contributions prove useful for the study of scientific normativity from a variety of perspectives. Although the tendency towards a study of scientific practices in philosophy has been based, to a great extent, on studies of practices carried out within STS, the development of this movement and this philosophical program could offer today, both to the philosophy of science itself and to STS, the theoretical foundations for a complex understanding of the problem of scientific normativity that is common to both fields.

43 Philosophy and STS have different methodological orientations that presuppose different normative points of view; these may generate distance and difficulty in their possible dialogues and interactions, but can also mutually enrich their points of view. In philosophy of science and philosophy of technology, the focus still tends to be on generating normative perspectives of science and technology that lack a robust support in empirical analyses of scientific and technological practices, although more and more these disciplines are expected to present perspectives that are less aprioristic and more empirically adequate. As we have seen, STS scholars largely avoid the presentation of general points of view on science and technology, privileging description and attention to cases in their methodological orientation, rather than the formulation of any general normative point of view.

44 Nevertheless, without abandoning its descriptive empirical approach, in STS we have seen a meaningful expansion towards broader objects of possible study, for instance, a turn towards the analysis of networks and heterogeneous assemblages, or global analyses of scientometric studies, or global cases with general concepts that allow scholars to grasp broad phenomena, such as the notion of “regime”. In the same fashion, STS scholars are showing new concern with normativity in science, motivated especially by the way anti-science movements and the media industry have taken up and used many of the critical and de-constructive contributions of STS to manipulate

public opinion, generating controversies around a so-called relativism and to questioning scientific claims and research.

Historical Epistemology

45 With Thomas Kuhm's *Structure of Scientific Revolutions* (1962) as their starting point, interactions between the history of science and the philosophy of science have resulted in important changes in epistemological and methodological conceptions of science, and have generated an important empirical-conceptual connection between these two disciplines. Imre Lakatos (1971) described this connection in Kantian terms: "The philosophy of science without the history of science is empty; the history of science without the philosophy of science is blind." In the last two decades, these empirical-conceptual interactions have been greatly enriched by important contributions from STS emerging from the framework known as "historical epistemology".

46 This perspective has recently been highlighted in the historical and philosophical research supportedby the Max Plank Institute for the History of Science in Berlin, beginning in 1994 with Lorenz Krüger, and furthered in the work of Lorraine Daston, Hans-Jörg Rheinberger, and Jürgen Renn (Feest & Sturm, 2011, p. 286; Moreno, 2018, pp. 157-159). It has become a broad research program focused on the study of the historical constitution of concepts, objects of study, and research dynamics in science, on the basis of an analysis of scientific practices.

47 This program, which is both historical and philosophical, presupposes a point of view that is not based in the reconstruction of social contexts, controversies, the establishment of beliefs, as was the case with the history of science in the 80's and 90's under the influence of the sociology of scientific knowledge (SSK); rather, it is a history of research practices that takes into consideration the material culture of science and the processes of constitution and stabilization of concepts, objects of study, and the dynamics of science, by means of heterogenous agencies. Undoubtedly, insofar as it assumes as its starting point the study of research practices in a sense that is not merely representational but also active and material, it is a historical perspective inserted in and informed by the knowledge of the contributions and the theoretical legacy of the STS field. As Daston (2000, p. 3) affirms, "These are not only stories about how interpretations of the world succeed one another, a *vita contemplative* of scientific objects. They are also stories of the *vita active*, of practices."

48 The term "historical epistemology" was used by some authors at the beginning and the middle of the 20th century, such as Gaston Bachelard, Georges Canguilhem, and Dominique Lecourt, in the context of the history of science and French epistemology, with different meanings[8], and it has been taken up again decades later by other authors, such as Lorraine Daston, Hans-Jörg Rheinberger, Jürgen Renn, and Ian Hacking, in all cases without a direct connection with the former authors. However, between the initial use given to the term in the history and epistemology of French science and its current use, there have been important transformations related to the historical study of research practices, as we have seen, on the basis of the robust and complex conception of practices developed within STS.

49 The historical epistemology approach, initially linked to the historical philosophical perspective proposed by Bachelard, is different from that of the history of epistemology, initially arising from the work of Canguilhem. The latter refers to the

study of the epistemological approaches of philosophers and scientists of the past, through the reconstruction and evaluation of arguments as they are presented in the classical philosophical or scientific texts, and with the purpose of understanding and assessing their meaning in relation to current approaches. In contrast, historical epistemology focuses on the understanding of various aspects of the science of the past, such as the emergence of new epistemic concepts and objects, or epistemic standards, rather than the reconstruction of epistemic arguments and justifications. (Sturm, 2011, p. 311; Moreno, 2018, pp. 159-160).

50 According to Uljana Feest and Thomas Sturm (2011, p. 288), three versions or lines of development in historical epistemology (HE) can be identified in the historical research proposed particularly by Lorraine Daston (2000, 2007, 2009), Hans-Jörg Rheinberger (1997, 2010), and Jürgen Renn (1995, 1996, 2004, 2008), each with a different foundation and purpose. On the basis of the work of these three scholars, we identify three versions of historical epistemology: 1) Histories of epistemic concepts; 2) Histories of epistemic things; 3) The dynamics of long-term scientific developments (Feest & Sturm, 2011, p. 288).

51 Research projects along these lines have studied, for example, high-order epistemic concepts, such as objectivity, observation, experimentation, and probability; historical trajectories of research objects, such as cytoplasmatic particles, electrons, DNA, or phlogiston; and the long-term historical analyses of scientific developments, beginning with the cognitive resources and representational structures used by scientific communities over time to establish inferences or to organize knowledge systems.

52 Sturm (2011) identifies the following methodological characteristics common to the three mentioned senses of development for HE.

> Even though these versions of HE differ in their topics of study, they share important methodological characteristics. For instance, all prioritize the study of both the local contexts of science, as well as transcontextual comparisons across time and space – combining micro and macro history. Furthermore, all three share a common objective: to study research practices that lead to the introduction of, or modification to, concepts of objects and epistemic concepts, as well as changes in the development of scientific theories. These methodological commitments are rarely found in work on the HE (pp. 306).

53 In coherence with these purposes and orientations, we can affirm that these kinds of research programs have a hybrid nature, both philosophical and historical, based on a history of science transformed by certain approaches developed in STS. Nonetheless, and paradoxically, the methodological orientation of these perspectives, with their focus on detailed historical description, has led them to be overlooked by many philosophers of science, while their clear epistemological objectives have caused them to be overlooked by many STS theorists.

54 An approximation of these three HE perspectives along with the philosophical analysis of normativity in the scientific practices could help to underpin their epistemological nature as they lack, as pointed out by Sturm (2011) and Juan-Carlos Moreno (2018)[9], of a precise enough understanding about the implicit normative processes operating in scientific research practices and those upon which their epistemologies are based.

Philosophical Perspectives on Technology and their Interactions with STS

55 In the field of philosophy of technology, during the last three decades some foundational encounters with STS have also brought about important transformations and turns in the understanding of technology proper to classical philosophy of technology of the early and mid-20th century.

56 The most important movement of transformation in this field, arising out of a close interaction between particular philosophical reflections and certain approaches from STS is known as the "empiricist turn" in philosophy of technology. According to Philip Brey (2010) and Hans Achterhuis (2001), in the 1900's some neo-heideggerians, neo-critical theorists, and post-phenomenologists began to focus on specific technologies and concrete issues; they sought to develop contextual and less deterministic theories of technology or borrowed them from STS, and they began to assume less dystopic and more pragmatic approaches centered on an analysis of the mediating role of concrete technological objects. This implied a sharp criticism of the former philosophy of technology and its homogenous, totalitarian, and little differentiated reflections on modern technological culture, and its commitments to essentialist and transcendental presuppositions.

57 In this way Andrew Feenberg, for instance, developed a theory of technology within the framework of Critical Theory, borrowing a number of elements from STS to emphasize the contextual nature of technology and the possibility of differentiated technological development (Feenberg, 1999). Don Ihde founded and developed the field of "post-phenomenology", a less evaluative type of phenomenological analysis of technology, freed from the metaphysical commitments of classical phenomenology and focused on the mediating role of technologies in human experience and forms of existence (Ihde, 1990, 2009). In close dialogue with actor-network theory, this perspective has become one of the main methodological resources for the empirical analysis of the mediating material role of technological objects. And the neo-heideggerian philosopher Hubert Dreyfus analyzed in great detail some concrete research programs on artificial intelligence, particularly observing agency processes (Brey, 2010, p. 39).

58 In general terms, as the philosophy of technology started to interact more with fields like STS, cultural studies, and communication and media studies, these interactions led to an integration of ideas within the field that stimulated a more empirical, less determinist, more descriptive, and less evaluative view of technology.

59 This empirical turn became even more radical with the emergence of the "second empiricist turn", promoted by scholars like Joseph Pitt, Peter Kroes, and Anthonie Meijers. They argued as follows: the problem with classical philosophy of technology is the meager connection it has with technologies themselves, in their concrete and material terms; this is the result of an overriding interest, in both the classical philosophy of technology and the SCOT program, in the meanings and social consequences of technological constructivism. Pitt, in his *New Directions in the Philosophy of Technology* (1995), and Kroes & Meijers in their *The Empirical Turn in the Philosophy of Technology* (2000), argue that the philosophy of technology must be more oriented towards engineering, and ought to focus on description rather than on evaluation.

60 One of the pioneers of these ideas was Carl Mitcham, who, in his book *Thinking Through Technology* (1994), proposed that philosophy of technology should be focused on the development of descriptions of technology and its internal functioning, rather than examinations of its external consequences. This approach pervades *Philosophy of Technology and Engineering Science* one (2009), edited by Anthonie Meijers and with the contributions from a number of authors. And in Sacha Loeve, Xavier Guchet, and Bernadette Bensaude-Vincent's *French Philosophy of Technology. Classical Readings and Contemporary Approaches* (2018), we see a similar turn towards concrete technological objects, one that could be characterized as a "turn to the thing" *à la française.*

61 These empiricist turns have had particular repercussions for the moral analysis of technologies proposed by many current philosophers of technology, such as F. Brey, P. Kroes, A. Meijers, P.P. Verbeek, etc. In the context of this article, it is important to pause for a moment to highlight Verbeek's contributions regarding the moral relevance of technological artifacts (Verbeek, 2005; 2011), as in them we can identify a fluid interaction between philosophy of technology and particular approaches from STS leveraged in the study of the moral mediation exercised by artifacts. Verbeek connects an orientation towards descriptions from Ihde's post-phenomenological perspective with actor-network theory's conception of the sense of agency. In this way he achieves a detailed explanation of how artifacts mediate our perceptions, judgments, and moral actions (Moreno, 2019, pp. 91-118).

62 As these examples demonstrate, there is a wide range of constructive interactions between the recent philosophy of technology and some STS approaches to the study of technology. These interactions have engendered the development of novel analyses for the study of technologies.

Shared Interests and Convergences in Points of View

63 Regrettably, these philosophical approaches that have established transdisciplinary encounters with STS have not received more attention from the wider communities of experts in both fields. As Rouse (2011, pp. 12) notes, attention to and further study of these perspectives has only been common within a few specialized circles and communities. These communities share a common axis of interest in the construction of alternative conceptions of science and technology, and out of this interest arise some important points of convergence between philosophy and STS.

64 First, the philosophical perspectives we have highlighted, whether they emerge from philosophy of science or philosophy of technology, show a clear orientation towards empirical analyses. These analyses have taken up from the emphasis on case studies in STS and have been incorporated into philosophical reflection, as in the case of the philosophy of laboratory experimentation; they have been developed through an appropriation of certain STS methodologies, as in the case of historical epistemology; and they have also helped to generate an empirical turn in some traditional philosophical methods, as is the case of the post-phenomenological perspective recently developed in philosophy of technology. These different forms of empirical analysis are examples of how philosophers have taken up the STS orientation toward empirical research.

65 Second, in these perspectives we can see a shared interest in the "Pandora's Box" that has opened, particularly within STS, regarding the study of scientific and technological practices. STS has opened for philosophy many paths of access to the nebulous field of the study of practices. In general terms, these philosophical traditions share an orientation towards the study of science and technology from the empirical and material ground of practices, rather than the representationalist and rationalist emphasis of the philosophical tradition. These have been interpreted in different ways: in the social, cultural, and material sense, as the actions of the *in situ* science; in an epistemic sense, as mediators of experience, knowledge, and the construction of objects; and as substratum and support of the normativity with which science and technology operate.

66 Third, in relation to this latter sense, we see in these philosophical approaches a common interest in analyzing the ways in which the normative conditions of science and technology are constituted and defined through practices, as opposed to an aprioristic conception of these normative conditions, or the adoption of prescriptive and evaluative approaches that has traditionally been the starting point for the philosophical study of science and technology. This change has been made possible by new orientations taken up from STS, such as a commitment to the observation of scientists at work, not taking objects of study objects or facts for granted, and a turn to the objects themselves, (etc.), in place of the assumption of a prescriptive or evaluative point of view that might ignore, exert bias on, or limit understandings of the complex, heterogenous and dynamic aspects of scientific knowledge and technological development.

67 As we have argued, in these axes of common interest we see important points of encounter, convergence between philosophy of science and technology and STS. Between two such wide and differentiated fields there exist many other possibilities for the transdisciplinary construction of novel perspectives, like the contributions from this thematic dossier, summarized in what follows.

Contributions to the Dossier

68 The articles that make this dossier up propose new pathways of encounters between philosophy and STS, using case studies from research on physics, chemistry, biology, and mathematics in relation to the following topics: the conception of time-landscape in science, the politics of the closed fuel cycle in the nuclear energy industry, the epistemology of field sciences, the constitution of the live cell as epistemic object, and the influence of certain social dynamics in the development of applied mathematics. In brief, the contributions in this dossier develop the following approaches:

69 In the first article, titled *D'âges en paysages : une perspective critique sur « l'âge de l'atome » croisant STS et philosophie des techniques,* Bernadette Bensaude-Vincent argues for the adoption of the conception of timescape, a category proposed by Barbara Adam that refers to time from a meteorological point of view, for understanding technological and planetary changes, rather than the lineal chronological time or the timeline that is presupposed by most scientific theories. Working from a case study of the analysis of different ages of atoms as they can be identified in some radioactive materials produced by the nuclear energy industry, Bensaude-Vincent questions the use of a lineal chronological time that organizes the transformations of radioactive materials

and energies towards either progress or catastrophe, affirming instead the need to adopt the notion of timescapes. Weaving an eloquent, current, and relevant web of connections between several disciplinary fields, the author challenges the modern determinist assumptions of chronological time, proposing in their place a situational, contextual, internal, and immanent conception of time. Understanding time in this way allows her to shake up anthropocentric orientation of narratives about the Anthropocene narratives and set about constructing an alternative orientation, from which the complexity of social and technological changes associated to this new geological era can be confronted. In accordance with various perspectives in STS and philosophy of technology, this change in our conception of time supposes a turn towards a plural and flat ontology that acknowledges the particular ontological conditions of singular entities and the symmetry between the agencial or performative capabilities of things, natural entities, societies, and persons.

70 In the second article in this dossier, "*Le pouvoir et les opérations. Comment comprendre l'écologie imaginaire du « cycle du combustible nucléaire »",* Ange Pottin analyzes the French government's "closed fuel cycle" policy of the 1970's, focusing particularly on the imagined possibilities for the regeneration of radioactive residues of nuclear reactors ultimately into fuel, and on the social implications of this policy. She builds a fluid dialogue between contributions stemming from philosophy of technology and STS to analyze the case study in the context of Gilbert Simondon's criticism of technocratic culture and Sheila Jassanof's conception of the social role of technical representations and imaginaries. She uses Simondon to show the contradictions between the possibilities imagined by the technocratic mentality, formulated around its interest in the maximum profitability and efficiency of the energetic system, and the possibilities for material transformations through technical operations. Through Jassenof she analyzes the political function or role played by social-technical imaginaries, especially with regard to the sustainability and efficiency of such policies. One of the main aims of the encounter between these perspectives as staged in this text is to integrate Simondon's normative approach with Jassanof's descriptive approach.

71 In the article "*Pensando epistemologías desde el campo"*, Ezequiel Sosiuk and Emiliano Martín Valdez study the still largely ignored epistemology of the field sciences. The authors show that the field is a place of knowledge production, with quite specific conditions, just like the laboratory, and the analysis of its epistemology can be as relevant and meaningful for the studies of science as was the analysis of the epistemology of the laboratory. The authors examine at length the special conditions with which scientific research is developed in the field in the light of contributions from recent studies of field sciences, as well as other contributions from STS and philosophy of science. These show that some of the most important conditions for field research are, as follows: it implies the contextualization of the objects of knowledge, insofar as field work must operate in a setting not designed for research; it also implies the production and mobilization of knowledge to control and organize the place of work; and, finally, field work requires an adaptation of experimental practices, separate from their development in the laboratory. The study of the epistemological conditions of the field sciences enriches our understanding of the ways in which scientific research develops differently in different production sites.

72 In the following article, "*Fenomenotecnia y Sistemas Experimentales: el caso de la Célula Viviente,"* Juan Carlos Gallego-Gómez and Germán Guerrero Pino analyze the

constitution of the live cell as an epistemic object, arise from an assemblage of many material experimental processes, initially developed in the fields of cellular theory, cytology, and biochemistry, then in microcinematography, fluorescent microscopy, and confocal microscopy, and most recently in the field of live cell imaging. Using the concepts of phenomenotechnique, proposed by Bachelard, and experimental systems, as presented by Rheinberger, the authors interpret the emergence of the live cell as a new space of representation, previously nonexistent, and show how the notion of experimental systems allows them to broaden and make more precise the notion of phenomenotechnique. By connecting contributions from philosophy of science and the STS, the authors show that the different experimental systems involved in the constitution of the live cell as an epistemic object were scientific elaborations produced in laboratories that implied the convergence of local, technical, instrumental, institutional, social, and epistemic perspectives. The complex assemblage of heterogeneous aspects that is produced by experimental practices has not been properly understood within the traditional conception of science focused on the study of theories.

73 In the article titled "*Qu'est-ce qu'un théorème (en pratique)? Le rôle de la métamathématique dans la production des mathématiques*", Sylvain Lavau analyzes the constitution and consolidation of the scientific communities that promoted the development of the geometric control theory in the 1970's, using a bibliometric study about the quotation and co-quotation dynamics in the scientific publications belonging to this study field of applied mathematics. Through this case study, the author shows how the social dynamics of adherence and of discussion within an academic community were metamathematical elements that influenced the development of this theory. In particular, discussions concerning the adoption of geometric methods led to a change in perspective and to the consolidation of the academic community involved in the development of the geometric control theory. With this research, the author demonstrates the relevance of contributions from the sociology of mathematics for enriching the philosophical study of mathematical practices.

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NOTES

1. STS scholars normally study the approaches of some philosophical authors and perspectives as part of their disciplinary training, but this is not necessarily the case when it comes to the disciplinary formation of the philosopher of science or the philosopher of technology. On the contrary, approaches and contributions from STS are rarely considered.

2. The intellectual controversies during the 90's that were granted the epithet the "science wars" are widely known, and it is not necessary to explain them here. For an understanding of these disputes, refer to Gross & Levitt (1994), Sokal (1996), Ashman & Barringer (2001), Parsons (2003), and Callon (1999).

3. Hacking is acknowledged as the main pioneer in this new philosophy of experimentation. Refer to, for instance, Radder (2003, p. 1), or Ferreirós & Ordóñez (2002, p. 53)

4. Shapin offers a broad bibliographical selection on the studies of experimentation developed during the 1990's (Shapin, 2000, pp. 244-249)

5. In Vinck (2007) the precedents of laboratory studies from the aforementioned authors are explained, as well as other recent studies where this kind of research is revisited.

6. In Georges Thill one could find an anticipation to the dialogue between philosophy and STS as, being a physicist, philosopher, and theologian, he analyzed the creative, dynamic, social, and human sense of scientific practice in the laboratory. He described this practice as "an action which invents a utopia as part of the rational course of events", and discussed an "intrinsic demiurge to the scientific practice" (the fact of constantly present new situations in regards to the state of things), and the laboratory as "place to cancel social norms" (as sometimes happens with parties or carnivals) (Vinck, 2019, pp. 107-114).

7. https://philosophy-science-practice.org/

8. Braunstein (2012) identifies the first use of the term in Abel Rey's Ph.D. dissertation, in 1907. Canguilhem used it in the 1960's in order to highlight a distinction between the kind of work carried out by Bachelard, naming the first as "historical epistemology" while qualifying his own work as "epistemological history" (Becerra, 2016, p. 36; Tiles 1984, 1987). Later on, Dominique Lecourt (1969) reintroduced the term in French epistemology to refer to the type of epistemological analysis made by Bachelard. And the concept was extended as well to the epistemological approaches of others French historians and philosophers of science, such as Michel Foucault (Moreno, 2018, pp. 157-159).

9. Sturm (2011, p. 315) and Moreno (2018, pp. 172-173) discuss the insufficiently justified argumentative leaps in the three perspectives of HE concerning the understanding of the forms in which epistemological approaches are established from the description of practices and their normative conditions. For instance, in Daston & Galison (2007), the analysis of the historical constitution of objectivity is based on an historical analysis of the practices regarding seeing – and not on a theory of vision-, but they do so without analyzing the normative processes implicit to these practices upon which the epistemological approaches to objectivity are based. However, they affirm that the analyzed practices are philosophically meaningful, and then perform an argumentative leap when stating that the ideals or practical norms dictate not only how to see the world, but which are the scientific objects and how they must be known as well. In other words, these ideals and norms become the normative guidelines to establish what can be accepted as prove and what can be supposed as objective.

ABSTRACTS

The relations between philosophy of science, philosophy of technology and the field of Science and Technology Studies (STS) have been very broad and diverse over the past five decades, although distance, controversies and disputes have prevailed. Our analysis shows that in some specific philosophical perspectives on science and technology, unfortunately not yet well known, and in the wake of the "science wars" debates, a new scenario of novel and constructive encounters between these fields has emerged. These include: studies of experimentation, the practical turn in the philosophy of science, the development of historical epistemology, the empirical turn in the philosophy of technology, and new methods for interpreting the moral relevance of artefacts. This analysis of the encounters between the aforementioned philosophical

perspectives and the STS field stimulates and invites the development of other possible encounters such as those presented in this thematic dossier.

Les relations entre la philosophie des sciences, la philosophie de la technologie et le domaine STS ont été très importantes et diversifiées au cours de cinq décennies, même si la distanciation, les controverses et les différends ont prévalu. Cependant, l'examen des rapprochements entre la philosophie et les études STS montre qu'un nouveau scénario de rencontres inédites et constructives entre ces domaines a émergé, après l'influence des débats de la guerre des sciences, au sein de certaines perspectives philosophiques spécifiques sur les sciences et les technologies, malheureusement encore peu connues. En voici quelques-unes : les études sur l'expérimentation, le tournant pratique de la philosophie des sciences, le développement de l'épistémologie historique, le tournant empirique de la philosophie de la technologie et l'approche de la pertinence morale des artefacts. L'analyse des rencontres entre les perspectives philosophiques susmentionnées et le domaine STS peut servir à stimuler et à inviter le développement d'autres rencontres possibles telles que celles présentées dans ce dossier thématique.

Las relaciones entre la filosofía de la ciencia, la filosofía de la tecnología y el campo CTS han sido muy amplias y diversas a lo largo de cinco décadas, aunque han prevalecido los distanciamientos, las controversias y las disputas. Sin embargo, el análisis de las aproximaciones realizadas desde la filosofía hacia los estudios CTS, muestra que ha surgido un nuevo escenario de encuentros novedosos y constructivos entre estos campos, después del influjo de los debates de las guerras de la ciencia, en algunas perspectivas filosóficas específicas sobre la ciencia y la tecnología, lamentablemente aún poco conocidas. Algunas de ellas son las siguientes: los estudios de la experimentación, el giro práctico planteado en la filosofía de la ciencia, el desarrollo de la epistemología histórica, el giro empírico en la filosofía de la tecnología, y el planteamiento de la relevancia moral de los artefactos. El análisis de los encuentros realizados entre las perspectivas filosóficas mencionadas y el campo CTS, puede servir para estimular e invitar al desarrollo de otros posibles encuentros como los que se presentan en este dossier temático.

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Palabras claves: estudios sociales de ciencia y tecnología (CTS), filosofía de la ciencia, filosofía de la tecnología, guerra de la ciencia, transdisciplinariedad, práctica científica, giro empírico
Mots-clés: études sociales des sciences et des technologies (STS), philosophie des sciences, philosophie des technologies, guerre des sciences, transdisciplinarité, pratique scientifique, tournant empirique
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