TECHNOLOGICAL INNOVATION IN ENVIRONMENTAL INSTITUTIONS: BUILDING FOUNDATIONS FOR THE DESIGN OF THE "QUADRUPLE HELIX" WITH THE NANOTECHNOLOGY REVOLUTION.

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Justification/Motivation: A nanometer is a billionth part of a meter. From the laboratories, the results of these surveys get to industry and become products of various segments, which are already available for consumption. Thus, nanotechnology emerges as the most significant example of innovation in environmental institutions in recent times, which promises to change people's lives and is the scenario for the emergence of new rights, unprecedented in those existing so far. This is the context in which it is projected the emergence of a new concept of innovation, built through the arrangement of four helices: University, Industry, State and Human Rights. The relation between humans and the environment is circular. It should always be understood as something in which every human being exists and is one human being; applying the environment to every human being, means realizing the impossibility of human life without the environment. Research Problem: To develop an effective nanotechnology innovation concerned with the rights (of) human expressed in building conditions for a healthy human being and the preservation of the environment, is necessary creating a new concept of innovation which considers the four helices: University, Industry, State and Human Rights? Methods: The phenomenological-hermeneutic method that does not perform an external analysis, but an analysis in which the researcher is directly involved, as it relates to the object of research, interact with it and suffer the consequences of their results, their discoveries and potential. Thus, promotes the development of transdisciplinary research, necessary for the right can take account of the challenges brought by advances in nanotechnology, and with the case study. Discussion: The relation of the four helices is not always processed in the same way, because human life is changing, especially now from the reflections generated by nanotechnology, requiring new and appropriate responses to the new challenges produced. In the same vein, there is no man without nature; and nature is nature only through men and their language, as a condition of possibility for the attribution of this sense. Nanotechnology is transforming the relation that humans have with the environment, because nanoscale allows entrance into corners previously hidden, reproduction and modification of existing and known natural and human creations. The range of issues examined shows that besides the interaction between University, Industry and State, the Innovation Law of Rio Grande do Sul enshrines concern

with the ethical element typified by Human Rights and embodied by the concern for improvement of living conditions of society of Rio Grande do Sul – there is the question related to human beings – and also the concern with the environmental impact of the innovative project. Thus, the thesis of "quadruple helix" is confirmed and demonstrated in a concrete situation, elements that should be considered to evaluate an innovative project, especially in the area of nanotechnology. Expected Results: We intend to demonstrate how it is more than necessary, against the current reality of the nanotech era, the presence of a fourth helix, that inserts human rights-including the right to an ecologically healthy environment- in matters relating to laws on innovation. A case study which serves to illustrate the functioning of the movement designed to the four helices can be found in Rio Grande do Sul legislation on innovation. From the definition of innovation contained in Law number 13.196/2009, it was developed Decree number 46781 of December 4, 2009, which instituted the program PRÓ-INOVAÇÃO/RS and regulated that law. From this definition it is also possible to note that one of the fundamental guidelines of this program is underpinned by stimulus and support to innovative projects and companies that promote "care for the environment" in the state of Rio Grande do Sul.
Key words: Nanotechnology; Quadruple Helix; Human Rights; Innovation Law; Ecologically Healthy Environment.

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1. Introduction

The restlessness of human race is capable of entering untouched corners. This is the scenario in which nanotechnology is projected, a set of technologies, of various areas, but that have in common the manipulation of atoms and molecules on a scale that mediates between 1 to 100 nanometers. The scope of creativity that opens with nanoscale research aims at the imitation and recreation of nature. In it, the nanoscale has always existed. However, only now, human beings have scientific and technical conditions to access it.

This possibility creates a true scientific revolution, because nanotechnology does not fit the standards that are known and scaled yet. Nevertheless, there are also studies, although still very incipient, pointing risks in products that carry nanoparticles. It should be noted that there are chemical changes in works that are structured from particles in nanoscale, when compared to similar works that are built in other scales. The designed scientific context should balance the evaluation of benefits of nanotechnology, relating them to humans and to the environment. Both humans and environment will bear the positive or negative outcomes of these discoveries.

It is intended to investigate the necessary remodeling of the concept of innovation, gestated from the Manual of FRASCATI until the concept of Triple Helix in the terms developed by Henry Etzkowitz. Despite this, there is the importance of entering another cell: Human Rights, which will be responsible for the ethical shaping of knowledge capitalization. Therefore, the problem being studied may be limited as follows: under what conditions nanotechnology fits the concept of "Innovation in Motion" from the Triple Helix, and indicates the need to include a fourth cell, responsible for the inclusion of an ethical bias.

The objective of this research is to resize the concept of innovation of Etzkowitz, adding an element focused on the substantial perspective brought by means of Human Rights, based on the analysis of Brazilian Federal Law on Innovation, comparing it to the legal text of Rio Grande do Sul, which disciplines technological innovation using nanotechnology as an example to work with the "quadruple helix".

2. Nanotechnology And Human Creativity: Big Challenges With A Small Technology

As a starting point, showing the great potential of human creativity, it is to mention the realization of researchers from the University of Florida in the United States, who created a molecular nanomotor moved only by photons, the basic particles of light, and made from a single DNA molecule. The nanomotor was created by joining a DNA molecule and a molecule of azobenzene, a chemical compound which reacts to light. A low-energy photon makes these molecules to react in one way, while a high-energy photon causes another type of reaction. The size of this human creation should be pointed out: in its closed form, the nanomotor measures 2 to 5 nanometers. Under the action of light, by exerting his strength, the motor opens, stretching to reach between 10 and 12 nanometers.

According to the researchers, there are the following strengths: the performance of photonic nanomotor is not high; it is less effective than photovoltaic solar cells. However, its

major advantage is the direct conversion of light into mechanical motion, opening the possibility for nanoscale applications that are not possible with the traditional scheme used in macroscale, where electricity is used to power a motor, which makes the mechanical work; another advantage is that the nanomotor, being made of DNA, is biocompatible and can be used in developments aimed at applications in biomedicine. The research is still at an early stage, but it is already possible to envision positive aspects, especially their interaction with humans, given its compositional structure.[1]

This is a small example of the possibilities that protrude through nanotechnology. It is important to enhance that with the term nano a measurement is referenced, which means, it represents the billionth part of a meter or the following scientific notation: 10^{-9}. It is worth saying: "nanotechnology is a set of multidisciplinary techniques that allow the domain of extremely small particles (nanoparticles), showing completely new mechanical, optical, magnetic and chemical properties" (Dupas, 2009, p. 57, our translation). The most interesting aspect of research in nanoscale is the potential to build things from the manipulation of atoms:

> When we go to the very, very small world – say circuits of seven atoms – we have a lot of new things that would happen that represent completely new opportunities for *design*. Atoms on a small scale behave like nothing on a large scale, for they satisfy the laws of quantum mechanics. So, as we go down and fiddle around with the atoms down there, we are working with different laws, and we can expect to do different things. We can manufacture in different ways (Feynman, 2010).

It is verified that the properties and characteristics of things produced from the manipulation on nanoscale are different from those that exist in other than nanoscale. There is a warning point, because such changes must be examined, since there is risk of toxicity.

The development of nanomotors shows one of the possibilities of construction that humans will be able to develop, "correcting" the "imperfections" that Eric Drexler pointed out: "[...], human beings are very bad, very poor in making things. Almost everything that we could draw and design with atomic precision cannot be done at present. [...] Only now we are learning how to handle and to put in place the fundamental pieces of matter that make up everything". (Drexler, 2009, p. 46, our translation). The case of the nanomotor fits this characterization of Drexler perfectly. A question arises: what is the limit of the human power of creation to build things? By the announcements of possibilities brought by nanotechnology there is the impression that everything that humans want can be created and recreated. It must be present that in nature the nanoscale has always been part of the essence of many things. However, only now, humans are accessing the opportunity to develop and design things (materials, objects, products) with nano particles. As said on another occasion, two aspects cannot be overlooked: the concern about the consequences in relation to human beings and to the environment (Engelmann, 2009 and 2009a).

[1] Available at http://www.inovacaotecnologica.com.br/noticias/ Accessed on 02/01/2013. Reference used in this page: Huaizhi Kang, Haipeng Liu, Joseph A. Phillips, Zehui Cao, Youngmi Kim, Yan Chen, Zunyi Yang, Jianwei Li, Weihong Tan. *Nano Letters.* Single-DNA Molecule Nanomotor Regulated by Photons, June 5, 2009, Vol.: Article ASAP, DOI: 10.1021/nl9011694.

In a sense, human entry into the world of nanoscale opens possibility of building "new identities and new spaces"[2], with unknown magnitudes. In this scenario, there are inherently human concerns and ambiguities subject to be coped through practical reason. A rational attitude in condition to evaluate the positive and negative aspects, concerned with protecting humans and the environment (Engelmann, 2011). In this setting, two possibilities appear: a) each situation must be examined individually, which means, case by case, weighing the positive aspects and risks; b) the proposition of moratorium and the adoption of the precautionary principle. "The moratorium on any use of nanotechnology can be seen as a 'harder' way to adopt this principle. In its mildest form, the precautionary principle advocates a preventive action to be taken, even without scientific evidence of causal risks from nanoparticles". (Martins and Ramos, 2009, p. 50-1, our translation). Neither of the two alternatives seems to be the most appropriate, because in practice they would make unfeasible the continuity of research and of the already started production process with nanoparticles. The first of these alternatives would require a very large apparatus to get down to the specifics of each case. Perhaps possible when the manipulation of nanoparticles is in small numbers, but increasingly impossible, to the extent to which the production on nanoscale is increasing. The second option, blocks the continuity of research and of the production process. This would create obstacles to the advancement of nanotechnological innovation, being extremely difficult to justify.

The application of the precautionary principle does not authorize the mentioned position taking, because "this principle makes imperative all means that allow, for an economical and socially bearable cost, to detect and to evaluate risk, to reduce it to an acceptable minimum, and if possible, to eliminate it" (Lewicki, 2006, p. 361, our translation). It should be noticed that the adoption of the precautionary principle does not authorize the complete moratorium of research and uses of nanotechnology. The implementation of the precautionary principle requires care, analysis and rationally justified decision; not a pure and simple interruption. It is important to exercise caution in its use, so as not to detract from the purpose of the principle which has a close relation to risk management[3]. Consequently, to achieve the precautionary principle, it is essential to manage situations that generate risks by controlling the causes. But, this does not mean, in all of the cases, the stoppage of all that is generating risk. In this context, it is also necessary to include an ethics agenda to guide the practice of precaution that should mediate the tension between positive visions and precautionary actions (Throne-Holst and Sto, 2008, p. 99-100, our translation).

Examining how nanotechnology interacts with technology generated in other scales, they can be classified into two categories: a) in a first group there is nanotechnology "that promotes incremental innovation", which means, "they are technologies that manipulate structures in nanoscale of substances in macroscale, or said in other way, substances in macroscale that are handled by technologies that interfere in their nanostructures" (Martins, 2010, p. 10, our translation); b) the second group is occupied by "revolutionary innovations promoted by nanotechnology, which include technologies that build mechanisms on

[2] Expression adapted from SILVA, Marise Borba. Nanotecnologia e a criação de novos espaços e novas identidades. IN: *Cadernos IHU Ideias.* São Leopoldo: Unisinos, year 8, n. 139, 2010, 18p.

[3] About the theme, consult: Engelmann, Wilson; Flores, André Stringhi e Dossena Jr., Juliano. O Princípio Fundamental da Precaução: o Fascínio da Criatividade e os Desafios (Humanos) das Pesquisas com o Emprego de Nanotecnologias. IN: *Anais do IV Workshop em Nanociências da UNIFRA,* held on September 14 to 16, 2009. 1 CD. ISSN 2175-6856.

nanoscale to be used in environments of macroscale" (Martins, 2010, p.11, our translation). In the first group there are things to be improved, increasing the possibility of their use in smaller quantity, lighter, more resistant, besides other characteristics, impossible without manipulation of atoms and molecules. That is, what already exists will be improved, there is the increment. The second group is considered as a pure innovation, given the novelty and originality of which will be produced by means of nanoscale. Both groups will be responsible for certain effects and characteristics, which could be as follows:

a) In the implementation of incremental innovations of nanotechnology, it is possible that the following situations will have to be faced:

a. The time and environment in which they develop are fundamental and need to be tackled politically;
b. They affect industry and political spheres of society;
c. "Differences between previous discontinuities (incremental innovation arising from other technologies) and those arising from nanotechnology are only of levels";
d. "Changes in industries will always be forced and risky, however, already seen in other occasions";
e. "Policies will be aimed at particular products and not at nanotechnology itself";
f. A case by case analysis will guide the studies and policy proposals;
g. "The effects will be similar to semiconductors, synthetic polymers, wireless telecommunications, etc." (Martins, 2010, p. 11, our translation).

b) Revolutionary innovations generated from nanotechnology should be guided by the following characteristics:

a. Society will be confronted with unprecedented issues, "at allowing humans to manipulate the world in unprecedented scale";
b. Nanomachines – as the molecular nanomotor initially described – open a new frontier where there is no regulation that ensures the safety and productivity of this activity;
c. "They have different qualities and properties that will generate new questions of responsibility and control that are linked to three items: invisibility, mobility and self-replication". These aspects will generate new rights in different sectors of society and of environment;
d. "It is necessary to rethink legal basis and normative structures of society. Three aspects are important: monitoring, property and control". (Martins, 2010, p. 11-2, our translation). This necessarily will require the development of a new way of visualizing the Sources of Law, stressing the need for valorization of legal pluralism, promoting a dialogue between the sources of Law (Engelmann, 2010a).

The issues raised will require decision making, with attention of various segments such as the economic, political, social, scientific, but, above all, considering the positive and negative probabilities in relation to humans and to the environment. Therefore, decisions cannot be made without a deep concern for the impact they generate. Thus, according to Gilberto Dupas, it is necessary to resolve the conflict that is established between the freedom of the individual and the hegemonic impositions of society (2009, p. 83, our translation). In this

scenario, it seems that in discussions and decisions to be made should be included a return to human values, or "the need to resume ethical values as a reference for the discussion about the future of science in general, and of nanotechnology in particular". Hence, "there is no solution to the main problems of mankind if the public space does not return to control private interest. And mainly rediscover common human values that can mark out our future as a species" (Dupas, 2009, p. 85, our translation). The return to ethical values means, regardless of the name that it can receive, to place human beings and the environment as essential and nonnegotiable agenda. For this management, standards of public interest should override private interests. It will be necessary to look carefully at the text of the Constitution, in which are the guidelines of community life, which should be applied to individual decisions. This is the guarantee that decisions will be guided by collective welfare, respecting the individuality of each case.

Even though there is no specific regulatory framework, the characteristics following outlined must be considered: the universe continues populated by humans and all questions should be addressed with a minimum of civility, guided by "moral feelings of obligation and guilt, censorship and forgiveness". It will be necessary to adapt "practices of the world of life and of the political community to the assumptions of the moral of reason and to human rights", because these assumptions provide "a common base in favor of human dignity above ideological differences" (Habermas 2004, p. 101). So there are some guidelines for a decision making that is capable to mediate the great possibilities of nanotechnology. And there is no other humanly acceptable alternative, than returning to the single element which in essence does not change, which is, the humanity of human beings.

3. "Nature As Text": Possibilities Of Philosophical Hermeneutics To The Axiological Introduction In The Construction Of An Innovation Concept.

The scope of high technological potential can not underestimate the following aspect: all results – whether positive or negative – will be borne by human beings and by the environment. Thus, we should not forget a supreme ethical requirement: "the irreducible human":

> There is negation of human not necessarily when there is attempt on life, but when, in one form or another, there is attempt on what we call, with a severe and profound word, *human dignity*, which means, that allows human beings to value themselves as being of blood, elevating them to more than just their biological reality, pronouncing a word that they can really assume, by which they can express themselves (Jean Ladrière *in* Delmas-Marty, 2004, p. 185, our translation).

Here there are designed some fundamental ethical assumptions for this moment. Human beings have to be considered not only as something biologically available in laboratory, as a mere material of study, reproduction and improvement. On the contrary, human is something much more essential: a being of flesh, bone, feelings, and a fundamental constitutive element: human dignity. This dignity does not project into test tubes, but it is the result of long and arduous path of tradition of struggles, suffering and conquests, and that may not be reproduced in laboratory. In other words, it is an effective evolution, which is the result of simple living with other humans, with equal dignity.

It is precisely in this space that the reflection about the binomial "human" and "non-human" should be started, because it reveals "that the evolution of the representation of values of universal vocation is late and undoubtedly unfinished" (Delmas-Marty, 2008a). There are the acts of barbarism which have outraged the conscience of mankind, which are part of the pre-human understanding. Precisely, the acts against those deemed "non-human" – therefore, available for any kind of scientific research – that should not be forgotten, since this categorization affects human dignity with death. This is the path of tradition in which humans are inserted.

This binomial gets a new reading, from the time that the look to "future generations" is taken to debate, including the concern for environment. Thus, it could be stated that "non-human" is an extension of "human", which means, a healthy environment is necessary for the development of any person. With this, it is generated the expression "humanism in relation": "of relation, it would be a way to build a relation, and I speak of legal relation, from human to animal and, extensively, from human to nature" (Delmas-Marty, 2008). It is precisely in this unprecedented relation established between human and nature / environment – between human and non-human – that arises a new context for the topic of liability, based on the so-called "security requirement" (Viney, 2008). Until then, the liability covered only the relation between human beings. It also will be possible to plan, by this bias, the inclusion of "healthy environment" as a new right of personality.

From the characterized scenario, which corresponds to the substantial scope of the fourth helix, arise possibilities for the emergence of "nature as text" (Villarroel, 2006) and of a new philosophy in science (here understood in its broad vision encompassing all areas of knowledge)[4]. The construction of the foundations of this approach – mediated by hermeneutic phenomenology[5] – will be permeated by tradition and language. Therefore, the following alert should not be forgotten:

> [...] That language does not constitute the true hermeneutic occurrence as language, as grammar or as lexicon, but at what has been said in tradition, which is, at the same time, appropriation and interpretation. So it is here where it can be surely said that this occurrence is not our action in the thing, but the action of the thing itself. (...). (Gadamer, 2002, p. 672, § 467, our translation).

Tradition provides the historical horizon where there are projected events of the past, which should enlighten the development of scientific knowledge justification wrought by means of nanotechnology.

In the movement of hermeneutic circle, the pre-understanding precedes understanding / interpretation / application that will give meaning to nanotechnological discoveries, in which the researcher is directly involved. This same set should envisage nanoscale investigations,

[4] To further see, consult: Engelmann, Wilson. A nanotecnociência como uma revolução científica: os Direitos Humanos e uma (nova) filosofia *na* ciência. IN: Streck, Lenio Luiz e Morais, José Luis Bolzan de (Orgs). *Constituição, Sistemas Sociais e Hermenêutica:* Yearbook of the Graduate Program in Law – Master and Doctorate – UNISINOS, n. 6. Porto Alegre: Livraria do Advogado, 2010.

[5] This is also the methodological orientation of construction of the research here presented. It is important to say that the researcher takes part of the context in which nanotechnological research is developed, being exposed to its consequences – whether positive or negative. Therefore, the phenomenon of research on nanoscale is not out of the world to which the researcher belongs to. Furthermore, this phenomenal set will receive meaning attribution, from pre-understanding, moving the hermeneutical circle.

from the experience of the researcher, through their pre-understanding of the world, of life and of the results that human investments in nature have caused. Human beings, including the researcher himself, have always been inserted in a context where novelties in nanoscale are produced and generate their effects – positive or negative.

Therefore, the hermeneutic situation mentioned by Gadamer has perfect relation with the scenario of technological innovation raised by nanotechnology: "[...] interpretation has to find the correct language, if it wants the text to actually talk. Consequently, there cannot be a correct interpretation 'in itself', because in each case it is the text itself". There is no reproduction of a case, when much, there can be a relation of similarity between two situations, but not of equality. So, in nanotechnology, the case by case analysis should notice this detail: "[...] the historical life of tradition consists in its dependence on new interpretations and appropriations. A correct interpretation itself would be a thoughtless ideal, unable to know the essence of tradition. Each interpretation is bound to fit the hermeneutic situation to which it belongs". (Gadamer, 2002, p. 578, § 401, our translation). The relation between humans and environment projects this kind of situation that requires (responsible) decisions with specific outlines for each case. Anyway, the tradition of the interpreter, of the situation and of the researchers should be projected into the historical horizon, taking from it the learning of past experiences with the use of revolutionary technologies. Hence, hermeneutics discussed here does not apply solely to legal field, but to the field of scientific knowledge as a whole, also permeating the scientific areas that do not deal directly with these concepts. A paradigmatic case is to consider "nature" as "text" that should receive meaning attribution in order to continue serving as a shelter (home) to humans.

This is the basis to develop an ethical reflection on the relation among "human-technique-nature" (Villarroel, 2006, p. 173, our translation). To do so, it will be necessary to (re) pose the question of co-belonging between human and nature, which can go beyond the mere control and domination of the forces of nature by man, as both "[...] can come to need each other [...]", in a kind of "neighborhood between Human and Nature [...]", where "they are both one in front of the other, and each of which inevitably contributes to the proximity of the other" (Villarroel, 2006, p. 185, our translation). There is a relation between human and non-human (nature). However, it is not a relation of superiority or priority, but of supportive reciprocity. Both need one another, and therefore must respect one another, each with their own characteristics and potential.

Humans need to realize, as an occurrence, that nature is not available to be appropriated and exploited to exhaustion. Reasoning must be modified: nature exists to be cared for, because it is essential for human survival. This is the new responsibility of care that humans must learn to respect and consolidate.

Aware of it, philosophical hermeneutics also argues that one cannot think of the text as something that might be appropriated; forcing it (the text) to reveal its meaning and scope, but meaning should be attributed to it, respecting its limits. Thus, nature must also receive attribution of meaning – that is human care and responsibility in order to continue existing. This is the space for nature to appear as text.

The relation between humans and the environment is circular. It should always be understood as something in which every human being exists and is one human being; applying the environment to every human being, means realizing the impossibility of human life without the environment. This relation, however, is not always processed in the same way, because human life is changing, especially now from the reflections generated by nanotechnology, requiring new and appropriate responses to the new challenges produced.

In the same vein, there is no man without nature; and nature is nature only through men and their language, as a condition of possibility for the attribution of this sense. Because of this, it should be considered "nature as text", that must be interpreted, cultivated, cared for and respected to generate the norm, that corresponds to the relation of co-responsibility of all men in the preservation of nature.

That is the way to make it possible to introduce the axiological concept (the fourth helix) in the new contour of the concept of innovation, fundamental characteristic to make it possible to reinvent in the context of nanotechnology, as well as equip to provide answers that are appropriate and reasonable to times of modern technology. An ethical paradigm will be needed, as a thread that permeates the construction of the practice of innovation, in the molds that will be built hereafter, with the following characteristics (adjustment of contributions of Villarroel, 2006, p. 217 *et seq*, our translation): a) ethics that has certain standards, not utopian but practical, of reasonableness, concerned with human action; b) in the structuring of this ethics it is necessary to insert a thorough qualification for the environment, and a "requirement of adequacy or belonging" of mankind to this question; c) it is necessary a concern for the applicability or feasibility that a proposition of this kind should carry.

There arises space for the entry of the Aristotelian model of phronesis, prospected on a contextualized rereading with the current characteristics, notably its use concerning both "means" and "ends" elected by men to their full realization[6]. So in terms of hermeneutics it is proposed "an open ethics of human experience" that does not correspond to a "'neutral' description of objectivity" (Villarroel, 2006, p. 213, our translation), but that represents the pursuit for care for human and for environment, projected into the respect to limits, into moderation and into the construction of a "middle ground" that is not mathematically in the middle, but at a location where there can be assessed the needs of all generations – present and future – of human beings . Therefore, the management of "practical reason", which means, a reason concerned with human action, but concurrently with the development of (legal) standards capable to operate this itinerary. Special attention to this reason is necessary under penalty of producing monsters, or decisions that are irreversible, damaging the preservation of the humanity of human beings. This characterization is inspired by Goya's etching "The sleep of reason produces monsters".

Therefore, through phronesis – prudence, moderation, balance and weighing – it will be necessary to realize that "human rights carry a moral or ethical dimension that necessarily depends on a different rationality. And even reverse: universalizing, mobile, evolutional and flexible rationality" (Delmas-Marty, 2005, p. 284, our translation). Practical reason will be the appropriate rationality to account for the challenges that nanotechnology brings with it. Moreover, this rationality should not be neglected, but focused on human action, under penalty of producing irreversible results. These irreversible results appear if practical reason becomes careless or does not make proper practice weighing. That is, the manipulation of a utopian ethics, merely theoretical, can generate the monsters showed by Goya's etching.

This context of concern arises

> in lack of distance, [where] everything becomes in-different as consequence of the will of securing and empowerment that is uniform and calculator of the totality of earth. The struggle for domination of land entered its decisive

[6] To examine carefully the rereading of Aristotelian *phronesis*, consult: Engelmann, Wilson. *Direito Natural, Ética e Hermenêutica.* Porto Alegre: Livraria do Advogado Editora, 2007.

> phase. The full exploitation of land, by securing its domination, is only established when it conquers, off the ground, the extreme position for its control (Heidegger, 2003, p. 168, our translation).

The power awakened by nanotechnology fits this scenario because this power is in a hurry to install and does not allow the required distance for a reasonable decision making on the courses, limits and possibilities of research. This perspective is exacerbated by the methodology carried by scientific knowledge, which disconnects from reality, causing the scientist to develop their experiences without linking them to the world of life where they live in. That is why they have the impression that they can dominate the entire earth. There it is that phenomenological hermeneutics perspective intends to intervene in order to show that the scientist is part of the world where the results of nanotechnology will be perceived.

Because of all this it is necessary to "temporalize", that is, "to mature, let emerge", this that is processed in the "triple simultaneity" of the time of "strength of already being, making strength and await, this that protects us and we usually call future" (Heidegger, 2003, p. 169). Practical reason should be revalued so that rationality does not sleep, but at the same time let mature the issues relating to research and to results at nanoscale. Therefore, it becomes important to link past, present and future, extracting learning transmitted by tradition of human experiences in relation to already experienced technologies from this triple simultaneity.

Consequently, this is the path to the entrance of concern for humans and for the environment – an axiological perspective – in the (re) formulation of the concept of innovation in conditions of processing the positive effects brought by nanotechnology.

4. From Innovation to the "Quadruple Helix": Human Rights and Capitalization of Knowledge

The Organization for Economic Co-operation and Development (OECD) was established by the Convention signed in Paris on December 14, 1960; and entered into force on September 30, 1961. In June 1963, the OECD organized a meeting of national experts in statistics of Research and Development (RD), in the Italian town of Frascati. The result of this work was the first official version of the Proposed Standard Practice for Surveys of Research and Experimental Development. So was created the FRASCATI MANUAL: technical document that shows the role of science and technology through analysis of national innovation systems.

At this time, rapid technological changes, research and development (RD) constituted an important element for economic growth. The monitoring of efforts of RD made by industry, by government and by universities is the key to perform analyzes and carry out successful policies.

The Frascati Manual has become the internationally recognized methodological guide to compile and use statistics of RD, and it is an indispensable tool in statistical offices around the world. It includes definitions of key concepts, policies on data and ratings to be used in the compilation of statistical data. Through its internationally recognized concepts and classifications of its activities, the Manual contributed to intergovernmental debates about "best practices" in the field of scientific and technological policies. Technological innovation activities are the set of scientific, technological, organizational, financial and commercial

steps, including investments in new knowledge, leading or attempting to lead to implantation of products and new or improved processes[7].

As an extension of this Manual, OECD elaborated OSLO Manual, first published in 1990. It is the major international source of guidelines for the collection and use of data on innovative activities of industry.

The ability to determine the scale of innovative activities, the characteristics of innovative companies and the internal and systemic factors that can influence innovation is a prerequisite for the development and analysis of policies aimed at encouraging technological innovation.

According to OSLO Manual "technological innovations in products and processes comprise the implementation of technologically new products and processes and significant technological improvements in products and processes. One TPP innovation is considered established if it has been introduced on the market (product innovation) or used in the production process (process innovation). A TPP innovation involves a series of scientific, technological, organizational, financial and commercial activities. An innovative company in TPP is a company that has implemented technologically new products or processes or with substantial technological improvement during the period analyzed"[8].

In 2006, the third edition of OSLO Manual was elaborated. There it is possible to observe the following concept: an innovation is the implementation of a new or significantly improved product (good or service), or of a process, or of a new marketing method, or of a new organizational method in business practices, in the organization of workplace or in external relations[9]. The new edition brings a concept with modifications and includes marketing activities, among those that could generate innovation. Nanotechnology is inserted within the conceptual limits of innovation, featuring incremental innovation – when innovation aggregates some feature that is new and different from the existing product – and also revolutionary innovation – when occurs the introduction of a product, service, process, method or system that did not previously exist.

In Brazil, the prospect of innovation is enhanced in recent text, under Law number 10.973, of December 2, 2004, "Innovation Law", where is stated: "innovation: introduction of novelty or improvement on social or productive environment resulting in new products, processes or services" (art. 2, IV). It can be noted that its wording is very straightforward, and it is important to highlight that this law was drafted before the publication of the third edition of Oslo Manual. But Law number 11.196, of November 21, 2005, called "Law of Goods", which establishes tax benefits for innovative companies, considers "technological innovation as the design of a new product or manufacturing process, as well as the aggregation of new functionalities or characteristics to the product or process that involve incremental improvements and effective gain in quality or productivity, resulting in greater competitiveness in market" (Art. 17, § 1). Brazilian Law absorbs international perspectives on innovation – especially Frascati Manual and OSLO Manual – internalizing them through ordinary laws, which fall within the national plan to stimulate innovation in the country.Rio Grande do Sul, by means of Law number 13.196, of July 13, 2009, established the incentives for innovation and for scientific and technological research, considering as innovation the

[7] Available at http://www.reppittec.org.br/ArquivosUpload/1/File/Manual_de_Frascati.pdf Accessed on 20/01/2013.
[8] Available at http://www.finep.gov.br/imprensa/sala_imprensa/manual_de_oslo.pdf Accessed on 20/01/2013.
[9] Available at http://www.finep.gov.br/imprensa/sala_imprensa/manual_de_oslo.pdf Accessed on 22/01/2013, this definition is on p. 55 of the document.

"introduction of new products, processes, services, marketing or organizational innovation, as well as improvement of the existing ones, in productive or social environment aiming to expand company's competitiveness in local or global market and improve living conditions of the society of Rio Grande do Sul" (art. 2, I).

The path that has been developed in this study so far flows especially into the concept of innovation adopted by Rio Grande do Sul legislation, in which there is a clear concern for the improvement of "living conditions of the society of Rio Grande do Sul". This is the axiological perspective of Law and the openness for the valuation of human beings and of environment. It is in this scenario that the triple helix formed by University, Industry and Government is projected. Option is to adopt "State" instead of "Government" to be more comprehensive and enduring, under the inspiration of terms devised by Henry Etzkowitz (2009, p. 29, our translation).

Innovation, in this perspective, does not project only into products and processes, but into knowledge generated in / by University, which interacts with the prospects for development of Industry and receives fomentation resources through public policies promoted by State. The movement of the triple helix, which starts from a spiral, causes a true "capitalization of knowledge" and circulations in "macro and micro levels": "macrocirculations move along the helix, while microcirculations happen within a helix in particular. The first level creates policies, projects and networks of collaborations, while the second consists in the power of individual helices "(Etzkowitz, 2009, p. 28-9, our translation).

As an example of this movement of helices there is the Competitiveness Forum on Nanotechnology, sponsored by the Ministry of Development, Industry and Trade[10], which is situated in a macrocirculation of helices, precisely by its commitment to the formulation of public policies and of projects for regulatory frameworks on nanotechnology in Brazil. Besides this, participation in microcirculations also occur, from the moment that in this forum there is the participation of University and that there is an attempt to find legal and juridical alternatives to enhance the transfer of knowledge through specific assistance to industries working with innovation in nanotechnology, taking advantage of the resources provided by State.

This circulation can be characterized as follows: "(...) University is the quintessential institution designed to promote lateral movement, through its educational function. (...) Recently, lateral movement also occurred in upper levels of university, approximating administrators and teachers, with skills obtained in other social spheres and sending teachers to government and to industry, with the necessary expertise in these institutions" (Etzkowitz, 2009 , p. 29-30, our translation).

Although it is possible to see the chance of friction in the operation of the three helices, given the proximity between the roles of each of the actors involved, this does not happen, because "that is the bright side of institutional cross-fertilization, through which each helix is infused with new ideas and perspectives of others, through the circulation of individuals" (Etzkowitz, 2009, p. 30, our translation). Therefore, the construction of innovation through federal and state legislation in conjunction with Frascati Manual and OSLO Manual will occur via the triple helix.

In alliance with these aspects, the proposed model aims to cope with the challenge launched by Eric Drexler, when he reports the perception that he has of technological

[10] Available at: http://www.mdic.gov.br/pdp/index.php/politica/setores/nanotecnologia/80 Accessed on 02/02/2013.

evolution operated in countries like India, China, Japan and Korea. He says: "(...) In part, the reason I am in Brazil today is to try to better understand the role that researchers in Brazil can play in this process worldwide. I hope it is a very important role, so that Brazil can also contribute and participate" (Drexler, 2009, p. 52, our translation). There it can be seen that the movement of the triple helix that is the mainstay of innovation in Brazil still has to develop much so that Drexler's prediction can take place. The other countries mentioned above, especially China, Japan and Korea are on a growing level of research and innovation in nanotechnology. The examples of Nanopolis Suzhou – The Nanotech Commercialization Hub in China and NNFC Nano National Nanofab Center and the research in KAIST – Korea Advanced Institute of Science and Technology, both located in Seoul, South Korea should be mentioned.

It is the construction of a model called "knowledge-based economy", which means that it describes trends in advanced economies towards greater dependence on knowledge, information and high levels of expertise, and the growing need for immediate access to these factors by private and public sectors. Knowledge and technology have become increasingly complex, increasing the importance of interaction between firms and other organizations as a way to acquire expertise[11].

For this, some different initiatives are necessary. These initiatives may enable the installation of innovation in an organization, whether academic, industrial or in State or in any government department: innovation requires the use of new knowledge or a new use or combination for the existing knowledge. New knowledge can be generated by the innovative company in the course of their activities (which is, by intramural R & D) or externally acquired from various channels (for example, from the purchase of a new technology). The use of new knowledge or the combination of existing knowledge requires innovative efforts that can be distinguished from standard routines[12]. This article proposes the entry of another helix, creating a "quadruple helix", represented by Human Rights, which ethically supports the movement of the other three helices, ensuring the necessary integration of innovation with concern for humans and for environment. From this set of helices there will be a new concept of innovation[13] and an effective autonomy of human beings and of their creativity will be ensured, setting the "right to know" in the following terms defined in the Declaration of Technological Rights of Workers in 1981: "new automation technologies and the sciences on which they are based are product of a global accumulation of knowledge over several centuries. Therefore, workers and their communities have the right to participate in decisions and in benefits related to these developments". (Soderberg, 2013, p. 31, our translation). Here there is the key point for the installation of the fourth helix, as it intends to bring this perspective to the center of nanotechnological innovation with all living beings, with the environment and with the development of healthy conditions for a dignified life in community.

[11] Available at http://www.finep.gov.br/imprensa/sala_imprensa/manual_de_oslo.pdf Accessed on 02/02/2013, this definition is on p. 35 of the document.
[12] Available at http://www.finep.gov.br/imprensa/sala_imprensa/manual_de_oslo.pdf Accessed on 02/02/2013, this definition is on p. 43 of the document.
[13] This theme was object of a research Project entitled "As Nanotecnologias e o Direito: os Direitos Humanos como condição de possibilidade à regulamentação jurídica dentro de um cenário marcado pelo (novo) conceito de inovação"(Nanotechnology and Law: Human Rights as a condition of possibility to legal regulation within a scenario marked by the (new) concept of innovation) , developed in the scope of Edital MCT/CNPq N º 14/2010 - Universal / Edital MCT/CNPq 14/2010 – Universal, finished in November 2012.

A case study which serves to illustrate the functioning of the movement designed to the four helices can be found in Rio Grande do Sul legislation on innovation. From the definition of innovation contained in Law number 13.196/2009, it was developed Decree number 46781 of December 4, 2009, which instituted the program PRÓ-INOVAÇÃO/RS and regulated that law. From this definition it is also possible to note that one of the fundamental guidelines of this program is underpinned by stimulus and support to innovative projects and companies that promote "care for the environment" in the state of Rio Grande do Sul. (art. 3, VI).

Another aspect which fits the movement of the "quadruple helix" is in the part related to the aspects that will be taken into consideration for the design of incentives, in which, among other things, should be highlighted "the number of graduates, masters or PhDs company members; the existence of approved projects in institutions that promote innovation; the execution of research and development activities – R & D or the admission of specialized technical teams". (art. 6, II, III and IV).

To this Decree was added the so-called "Appendix A", to provide guidelines for the submission of the Consultation-Letter, which is aimed to request to the incentive mentioned in the program PRÓ-INOVAÇÃO/RS. In this appendix, it is stated that one of the documents that must be attached to the consultation-letter is the preliminary study of environmental impact, embodied by the submission of the environmental license or environmental license application of the innovative project.

The range of issues examined shows that besides the interaction between University, Industry and State, the Innovation Law of Rio Grande do Sul enshrines concern with the ethical element typified by Human Rights and embodied by the concern for improvement of living conditions of society of Rio Grande do Sul – there is the question related to human beings – and also the concern with the environmental impact of the innovative project. Thus, the thesis of "quadruple helix" is confirmed and demonstrated in a concrete situation.

The operation of each of the four helices highlights the necessity of breaking barriers and of building bridges, which are capable of, "from different starting points, achieving the common goal of economic and social development based on knowledge". (Etzkowitz , 2009, p. 194-5, our translation). Each of the four helices must open up to the other in order to facilitate the flow of knowledge through each of them, creating the possibility for "capitalization of knowledge" from the emergency "of dynamics within knowledge production". So it becomes practice through "transformation of knowledge into capital, and the processes by which this occurs, such as intellectual property rights and patent systems, corporate research labs and consortia, technology transfer and partnerships, venture capital (public and private), incubators, etc." (Etzkowitz, 2009, p. 197-8, our translation). This is the movement that nanotechnology is causing and will certainly be the means to innovative development of the State of Rio Grande do Sul and of Brazil, in order to occupy the place planned for Brazil in the projection of Eric Drexler.

5. Conclusion

Nanotechnology is transforming the relation that humans have with the environment, because nanoscale allows entrance into corners previously hidden, reproduction and modification of existing and known natural and human creations. This Scientific Revolution needs to be properly sized, because the positive and negative results will be borne by human beings and by the environment, where are the other living beings.

Studies of nanotoxicology are still incipient, but already indicate that there are risks that must be evaluated. Therefore, it is necessary to practice phronesis, ensuring prudent and careful analysis of risks and opportunities of allowing access to nanoscale creations. The contributions of hermeneutics, generated by Martin Heidegger and Hans-Georg Gadamer, will be a creative and reasonable methodological way to operate the research and the deliberation that this scientific moment demands. Therefore, nature must be regarded as "text" that through philosophical hermeneutics, will receive meaning attribution, showing that humans cannot survive without the environment. What is more is that the environment is the condition of possibility for (finite) existence of human beings. That is to say: the environment does not belong to humans. Rather, it is the human being who has a dependent relation with the environment. An example of concern of Law with this form of installation of innovation is the innovation law of Rio Grande do Sul, which improved the system created by federal law: Innovation Law and Law of Goods.

Thus, through capitalization of knowledge, which means, knowledge comes to develop a key role in society, it is ensured decision making that is favorable to human beings and to the environment, by the admission of practical reason, which must act within a certain time, taking certain distance and waiting for the maturation of ideas. In this context, the "triple helix", designed by Henry Etzkowitz – which establishes a relation between University, Industry and State, in order to characterize innovation – gets one more helix, formed by the group of Human Rights. Human Rights are not considered as mere theoretical guidelines for conduct and decision, but a space for dialogue, to which converge the attention and respect to human beings and to the environment. So there is one helix that is concerned with the axiological question in the construction of innovation.

The Innovation Law of the state of Rio Grande do Sul is a harmonic model and able to provide visibility for the four helices: scientific innovation, generated in Universities, is taken to the development of Industry, through the bridge fostered by the participation of the State, recognized through tax benefits, since there is concern with living beings within the ecologically balanced environment. These are the conditions that must be observed for the characterization of technological innovation.

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