The Earth and the cosmos in Humboldt - elements for the construction of modern Geography

ARTICLE

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ABSTRACT

This article presents an investigation into the epistemological foundations of Geography, which led us to the volumes of *Cosmos: A Sketch of a Physical Description of the Universe* by Alexander von Humboldt. The main objective is to understand Humboldt's conception of the universe and the Earth, based on the way he constructs his descriptions and interpretations of the interrelation between what he classifies, in his methodology, as the terrestrial and uranological realms. For this, the Spanish version translated by Eduardo Perié, along with volumes I and V in English, translated from German by Elise Charlotte Otté, and the first volume in French, translated by Hélène Blais, Jean-François Chauvard, and Jacques Rémy were used. This study highlights the pathways of Humboldt's vision that place Geography as a science dedicated to consolidating knowledge related to the organic and inorganic evolution of the Earth's surface, which, for Humboldt, would be the foundation for understanding space on macro and micro scales. This analysis also identifies essential roots in the construction of geographical knowledge and discusses their potential contributions to the development of contemporary geographical understanding.

Keywords: World. Geography. Universe. Science.

A Terra e o cosmos em Humboldt - elementos para a construção da Geografia moderna

RESUMO

Este artigo surge de uma investigação sobre as bases epistemológicas da Geografia, que nos levou aos volumes de *Cosmos: Ensaio de uma Descrição Física do Mundo*, de Alexander Von Humboldt. Nosso objetivo principal é entender a concepção de Humboldt sobre o universo e a Terra, a partir da maneira como ele constrói suas descrições e interpretações da interrelação entre o que ele classifica, em sua metodologia, como o reino telúrico e o uranológico. Para isso, utilizamos a versão em espanhol traduzida por Eduardo Perié, juntamente com os volumes um e cinco em inglês, traduzidos do alemão por Elise Charlotte Otté, e o primeiro volume em francês, traduzido por Hélène Blais, Jean-François Chauvard e Jacques Rémy. Neste estudo, destacamos os caminhos da visão humboldtiana que posicionam a Geografia como uma ciência dedicada a consolidar os conhecimentos relativos à evolução orgânica e inorgânica da superfície terrestre, o que, para Humboldt, seria a base para a compreensão do espaço em escalas macro e micro. Como resultado dessa análise, identificamos raízes essenciais na construção do conhecimento geográfico e discutimos suas possíveis contribuições para o desenvolvimento do saber geográfico contemporâneo.

Palavras-chave: Mundo. Geografia. Universo. Ciência.

A Terra e o cosmos em Humboldt - elementos para la construcción de la geografía moderna

RESUMEN

Este artículo surge de una investigación sobre las bases epistemológicas de la Geografía, que nos llevó a los volúmenes de *Cosmos: Ensayo de una Descripción Física del Mundo* de Alexander von Humboldt. Nuestro

objetivo principal es entender la concepción de Humboldt sobre el universo y la Tierra, a partir de la manera en que él construye sus descripciones e interpretaciones de la interrelación entre lo que él clasifica, en su metodología, como el reino telúrico y el uranológico. Para ello, utilizamos la versión en español traducida por Eduardo Perié, junto con los volúmenes uno y cinco en inglés, traducidos del alemán por Elise Charlotte Otté, y el primer volumen en francés, traducido por Hélène Blais, Jean-François Chauvard y Jacques Rémy. En este estudio, destacamos los caminos de la visión humboldtiana que posicionan a la Geografía como una ciencia dedicada a consolidar los conocimientos relativos a la evolución orgánica e inorgánica de la superficie terrestre, lo que, para Humboldt, sería la base para la comprensión del espacio en escalas macro y micro. Como resultado de este análisis, identificamos raíces esenciales en la construcción del conocimiento geográfico y discutimos sus posibles contribuciones al desarrollo del saber geográfico contemporáneo.
Palabras clave: Mundo. Geografia. Universo. Ciência.

INTRODUCTION

As with any scientific work, Humboldt's texts refer to a specific social context. The project for *Cosmos - A Sketch of a Physical Description of the Universe*, conceived in 1827 and published in 1845, addresses the discoveries and theories of that time, being strongly influenced by physics and the natural sciences.

After gathering a wealth of knowledge during his adventurous scientific journey, Humboldt published *Cosmos* at the age of 75. Inspired by various fields of knowledge, his influences included botany, geology, chemistry, mathematics, physics, astronomy and studies into terrestrial magnetism. His main objective was to identify general laws of movement in the constituent parts of nature, where, from an organicist perspective, the universe and the Earth are revealed as harmonious parts of the same whole: the Cosmos.

Humboldt's daring proposal was to rationally compile all the scientific knowledge about nature of his time, looking for commonalities between the different natural dynamics.

While conducting empirical work around the globe, Humboldt created and gathered some highly detailed field material. However, his approach was not limited to these direct observations; he also relied on external sources, especially travel reports, astronomical observations, physical and mathematical experiments. As a methodological choice, Humboldt opted to restrict his reflections to treating the data objectively "[...] with complete independence from the particular results"[1]. In this sense, the picture of nature constructed in his work describes the outside world objectively and is divided into two spheres: the celestial and the terrestrial[2], which are interpreted as general fields of telluric and uranological knowledge throughout the work[3]. The work titled "Cosmos - Descripción Física del Mundo" in Spanish, "Cosmos - A Physical Description of the Universe" in English and Cosmos - Essai d'une description physique du monde in French, both translated from the German "Kosmos – Entwurf einer physischen Weltbeschreibung" was named after the fusion between the theme of natural reproduction and the general laws provided by the exact sciences.

However, aware of Humboldt's intention to search for physical laws governing general movements, our aim is not to highlight the positivist aspects of his thinking, but to recover

[1] Translated by Author 1. In the original: "[...] con entera independencia de los resultados particulares" (Humboldt, 1875b, p. 1).
[2] Humboldt (1874b, p. 3).
[3] Humboldt (1874b, p. 3).

the methodology that allowed him to establish a transdisciplinary connection between terrestrial knowledge and that related to the universe. For this study, Humboldt's proposal for Physical Geography mixed theories of intensity and direction, which were at the basis of geographical traditions, with a novelty: the approach to physical theories of attraction and repulsion[4]. This movement strengthened geography's dialogue with the sciences that study space on a macro and micro scale, since Humboldt identified movements in terrestrial space that could be observed in all dimensions of space.

Guided by a mindset rooted in philosophical reason and mathematical rigor, Humboldt conceived of space as something in constant movement and transformation. This position reveals the complexity of nature, to such an extent that it transforms our planet into an inexhaustible source of study for the telluric sciences. Thus, Humboldt reinforces the role of geography as a fundamental science for understanding the world, which does not lose the planet as the central focus of its analysis, but still offers ways of understanding space in its broadest sense, transcending, without ignoring, the spatial knowledge of the Greek tradition[5]. To metaphorically paraphrase Lacoste (1988), Humboldt, even when encountering the cosmos, does not lose sight of the fact that geography serves, first and foremost, to understand the Earth.

Although the Humboldtian basis avoided the idea of a fragmented view of nature, the direction of contemporary science, driven by productivist practices, deepened the division of knowledge, resulting in an almost complete separation between Geography and the celestial sciences. Thus, we believe that, in modern times, Geography has faced practically the same problem that Morin (1995) pointed out in philosophy: "[...] the new cosmos has not penetrated our spirits, which still live in the center of the world, on a static Earth and under an eternal Sun"[6]. This distancing is concerning for this study, especially at a time when a range of activities with human and robotic presence take place in spaces that go beyond the limits of the earth's surface, which can obscure the real dimension of space for contemporary geographical studies.

PHYSICS BETWEEN GEOGRAPHY AND THE COSMOS

Although Humboldt endeavored to produce knowledge that views the Earth as part of the cosmos, his work makes no reference to the geography of other celestial bodies, which points to a possible move away from the proposal of a planetary geography found in the studies of Varenius (1671). Only in the third volume is there any mention of the stargazing work carried out by the geographer Guilhermo Jason[7] and the work of the geographer Joan Blaeu[8]. The latter is cited for his mistakes, i.e., mentioned only to justify what Humboldt considers to be the correct observations of the astronomer and mathematician Johannes Kepler, made in the 17th century.

However, strongly influenced by astronomical discoveries, which were mainly based on observation and the application of physical laws, Humboldt believed that knowledge about

[4] Humboldt (1875a, p. 55-56).
[5] This statement can be confirmed in the translation of Book III of Strabo published by Pereira and Deserto (2016).
[6] Morin (1995, p. 44).
[7] Humboldt (1875b, p. 145).
[8] Humboldt (1875b, p. 146).

the Earth could offer insights into natural behavior on other celestial bodies. By investigating volcanism, he suggests that other rocky bodies probably exhibit behavior similar to that of our planet.

> [...] While this activity results for the most part from the high temperature of the lower layers of the globe, it is probable that all celestial bodies that have been shaped by an immense release of heat and have passed from the state of vapor to the solid state should show analogous phenomena. The little we know about the configuration of the Moon is a further presumption in favor of this opinion; nothing prevents us from admitting, even on a celestial body devoid of air and water, the raising of mountains and this activity transforms a liquefied mass into crystalline rock. (Humboldt, 1875b, p. 145)[9].

Assuming that the formation process of a rocky celestial body is similar to that of the Earth, the physical geography proposed by Humboldt served as a guiding thread for understanding the dynamics of extraterrestrial nature. At the same time, uranographic knowledge confirmed laws of universal motion that helped to deepen our understanding of the position of the Earth and life in the cosmos. However, Humboldt is categorical in stating that studies of other celestial bodies belonged to a new field called Physical Cosmography[10], aimed at providing mathematical interpretations of astronomical observations.

Although it is necessary to be cautious when associating studies of the universe with the concept of geography, Humboldt admits that the progressive development of the conception of the cosmos, as a universal unity of the manifestations of the perceptible world, results from the expansion of knowledge stemming from historical and geographical studies.

> The history of the contemplation of nature, or the progressive development of the idea of the Cosmos, considered with reference to the historical and geographical facts that have led to the discovery of the connection of phenomena. (Humboldt, 1875a, p. 53)[11].

The accumulation of descriptive geographical knowledge generated up to that point served as a tool for correlating phenomena on different scales and allowing for a comprehensive interpretation of the relationships between distant spaces, highlighting space as a single, indivisible unit. Humboldt thus presented geography with a notion of space that, both on and off Earth, is continuous, interconnected and evolving.

Regarding physics, Humboldt identifies the Arabs as its true founders[12], stating that the translation of Arabian writings revealed concepts and laws that transcended time. In this

[9] Translated by Author 1. In the original: "...En tanto que esta actividad resulte en su major parte de la elevada temperatura de las capas inferiores del globo, es probable que todos los cuerpos celestes que han sido redondeados por un inmenso desprendimiento de calor, y han pasado del estado de vapor al estado sólido, deben presentar fenómenos análogos. Lo poco que sabemos de la configuracion de la Luna es una presuncion mas en favor de esta opinion; nada impide el que se admita, aun en un cuerpo celeste privado de aire y de agua, el lavantamiento de las montañas y esa actividad que transforma una masa liquefactada en rocas cristalinas (Humboldt, 1875b, p. 145).

[10] Humboldt (1858a, p. 382-383).

[11] Translated by Author 1. In the original: La história de la contemplación de la naturaleza, ó el desarrollo de la idea del Cosmos, segun la exposicion de los hechos históricos y geográficos que nos han levado à descobrir el enlace de los fenômenos. Humboldt (1875a, p. 53).

[12] Humboldt (1874a, p. 210).

way, physics is presented as one of the pillars of the Humboldtian methodology, responsible for illuminating the general properties of phenomena and for filling the gap between macro- and micro-scale knowledge of space. Physics also demonstrated the harmony of the cosmos through its calculations.

Therefore, Physical Geography, preceding Humboldtian thinking[13], goes beyond the classic idea of presenting natural phenomena in their intensity and direction. By drawing closer to physics, Humboldt incorporated the attraction and repulsion of matter into the analysis of natural dynamics.

In volume IV of Cosmos, dedicated in large part to telluric knowledge, Humboldt delves into the identification of general laws that govern terrestrial phenomena and that could be analogous to cosmic dimensions of nature, where the effects of the approximation to theories of physics are very evident. The work is extensive and divided into two parts. The first deals with a general study of the magnitude and shape of the Earth, while the second deals with a general exposition of the reactions of the Earth's interior on its surface.

In the first volume, Humboldt mentions Bernard Varenius (1671) as the first intellectual to understand the Earth as part of the Universe[14]. Varenius' studies influenced the understanding of nature by considering the subordination of the celestial to the terrestrial. Varenius made the first distinction between general geography (considered an absolute geography) and relative or planetary geography (which sought to relate terrestrial phenomena to external objects, such as the Sun and the Moon). The use of the skies to understand terrestrial nature is also characteristic of the studies of Hipparchus, cited by Humboldt as the creator of the scientific astronomy. Hipparchus appears as a pioneer in determining the position of geographical places by studying the celestial regions[15].

However, even though he was clearly inspired by his predecessors, Humboldt re-signified geography by moving against the geographical tradition of the time, placing the Earth as the key to understanding knowledge about the universe, and not the other way around, as his predecessors had done[16].

Although he did not establish geography as an autonomous university discipline - which Ratzel did in 1870 - Humboldt played a crucial role in showing concern about the gradual division of knowledge relating to the Earth from that relating to the universe, as can be seen in his own words:

> Beginning with the depths of space and the regions of remotest nebulae, we will gradually descend through the starry zone to which our solar system belongs, to our own terrestrial spheroid, circled by air and ocean, there to direct our attention to its form, temperature, and magnetic tension, and to consider the fullness of organic life unfolding itself upon its surface. [...] The delineator of nature must resist the tendency toward endless division, in order to avoid the dangers presented by the very abundance of our empirical knowledge. [...]. (Humboldt, 2000, p. 90)[17].

[13] For example, the course taught by Kant at the University of Königsberg between 1756 and 1796, was also called Physical Geography and worked with content and research very similar to that presented by Humboldt.
[14] Humboldt (1875a, p. 67-68).
[15] Humboldt (1874a, p. 172).
[16] Humboldt (1874b, p. 25-26).
[17] Translated by Author 2. In the original: "Depuis les profondeurs de l'espace occupées par les nébuleuses les plus lointaines, nous descendrons progressivement vers cette zone d'étoiles dont notre système solaire fait partie, jusqu'à la sphère terrestre avec son

Although Humboldt maintained his concern for the integration of knowledge, he also did not escape the trap of fragmentation. Despite presenting a rich and rare debate on the cosmos and pictures of nature, he fragments his work into sections and natural kingdoms. This phenomenon reflects an old (but still current) challenge of an ontological perspective, especially in a contemporary scenario characterized by productivist demands, which has resulted in the even more accentuated fragmentation of knowledge into specialized disciplines, a movement easily observed in contemporary geography[18].

The cosmos in Humboldt

Regarding the concept of Cosmos, Humboldt remarks:

> [...] I use the word Cosmos in conformity with the Hellenic usage of the term subsequently to the time of Pythagoras, and in accordance with the precise definition given of it in the treatise entitled 'De Mundo', which was long erroneously attributed to Aristotle. It is the assemblage of all things in heaven and earth, the universality of created things constituting the perceptible world [...] (Humboldt, 1875a, p. 70)[19].

This definition shows that, like the concept of geography, the concept of the cosmos has strong connections with the Greek tradition. In the historical context, the Hellenes had less technologically advanced resources for observing outer space and the micro scale, and philosophical, mathematical and theological interpretations were the main epistemological paths for understanding the macro and micro dimensions of the cosmos.

In the 19th century, Humboldt was in a technologically more advanced period than his predecessors, with tools and studies that allowed detailed descriptions of microscopic and celestial space, integrating microscopy, geography and astronomy into the field of spatial studies. Throughout Humboldt's works, his admiration for William Herschel is evident, as he is cited as a fundamental author in the development of methods for observing and measuring phenomena on an astronomical scale. Scientists such as Wright, Kant, Humboldt and Lambert found physical and observational proof for their speculations in Herschel. For Humboldt, Herschel was likened to an explorer who "[...] like another Columbus, penetrated into an unknown ocean, from which he beheld coasts, and group of islands, whose true position it remains for futures ages to determinate"[20].

In this sense, just as in geography and telluric knowledge in general,

> [...] the study of the cosmos cannot be considered a separate branch of the natural sciences. Rather, it fully encompasses the phenomena of the heavens as well as those of the earth; but it encompasses them from a

enveloppe gazeuse et liquide, avec sa forme, sa température et sa tension magnétique, jusqu'aux êtres doués de vie que l'action fécondante de la lumière développe à la surface. [...] La tendance à fractionner indéfiniment l'ensemble de nos connaissances est une démarche que le philosophe doit savoir éviter, sous peine de se perdre dans la myriade des détails accumulés par un empirisme irréfléchi [...]" (Humboldt, 2000, p. 90).

[18] As mentioned in Girotto (2013), Carlos (2017) ou Costa et al. (2014).

[19] Translated by Author 1. In the original: "[...] la palabra Cosmos, está tomada como la prescriben el uso helénico, posterior a Pitágoras, e la definicion muy exacta dada en el Tratado del Mundo que falsamente se ha atribuido a Aristóteles; es el conjunto del cielo e la tierra, la universalidad de las cosas que componen el mundo sensible [...]" (Humboldt, 1875a, p. 70).

[20] Translated by Author 1. In the original: "[...] like another Columbus, penetrated into an unknown ocean, from which he beheld coasts, and group of islands, whose true position it remains for futures ages to determinate" (Humboldt, 1858a, p. 87).

> certain 'point of view' which is the one from which the World can best be reconstructed. (Humboldt, 1874b, p. 23)[21].

Therefore, the cosmos does not only refer to extraterrestrial space, but integrates both the telluric and uranological realms, encompassing the macro and micro scales. It is a modern epistemological lens that promoted another perspective on space for Humboldt at that time, one that transcended scientific traditions without ignoring them.

CONTEXTUALIZING THE WORLD IN HUMBOLDT'S DAYS

It is not surprising that a text on natural sciences produced in the 1840s is strongly influenced by the studies resulting from the colonization of the Americas, which, within its violent context, provided a global vision of nature. Humboldt emphasizes in his work that this was "[...] the most important event in the history of the world"[22], because, in addition to expanding knowledge of natural diversity, it promoted advances in the nautical arts, in the application of astronomical methods and in the improvement of navigation calculations. These advances "[...] gave this era such a particular character, completed the image of the Earth and showed man the harmony of the world"[23].

In the technological context, Humboldt points to the 17th century as having been worthily inaugurated by the compound microscope and the telescope, two instruments that revolutionized scientific epistemology. These advances enabled "[...] the discovery of Jupiter's satellites, the crescents or phases of Venus and sunspots by Galileo, up to Isaac Newton's theory of universal gravitation [...]"[24].

> [...] To the history of the world belong the discoveries of the compound microscope, the telescope and the polarization of light belong, as they provided the means to know what is common to all organisms, to penetrate the most remote spaces of the sky and to distinguish light from reflected light, in other words, to recognize whether sunlight emanates from a solid body or from a gaseous envelope. (Humboldt, 1874a, p. 102)[25].

Although the telescope had existed for 240 years before Humboldt's studies, the continuity and improvement of these tools revealed, in the 19th century, a deeper and more complex universe than the six planets and one moon identified in the first observations. During the preparation of *Cosmos*, discoveries were made of new satellites of Neptune,

[21] Translated by Author 1. No original: "Aunque el lazo de causalidad que une á todos los fenómenos no esté conocido todavía suficientemente, el estudio del Cosmos no puede considerarse como una rama aparte en el dominio de las ciencias naturales. Mas bien lo abraza por completo, los fenómenos del cielo, como los de la tierra; pero los abraza bajo un cierto 'punto de vista' que es aquel desde donde se puede recomponer mejor el Mundo" (Humboldt, 1874b, p. 23).

[22] Translated by Author 1. In the original: "[...] el acontecimiento mas importante para la historia del mundo" (Humboldt, 1874a, p. 262).

[23] Tradução do Autor 1. No original: "[...] dieron á esta época um carácter tan particular, completaron la imagen de la tierra y manifestaron al hombre la armonia del mundo Humboldt (1874a, p. 261).

[24] Translated by Author 1. In the original: "[...] desde el descubrimiento de los satélites de Júpiter, de los crecientes ò de las fases de Venus y de las manchas del Sol por Galileo, hasta la teoria de Isaac Newton sobre la gravitación universal [...]" (Humboldt, 1874a, p. 200).

[25] Translated by Author 1. In the original: "[...] A la historia del mundo pertenecen los descubrimientos del microscopio compuesto, del telescopio y de la polarización de la luz, porque han suministrado los medios de conocer lo que es común a todos los organismos, de penetrar en los mas remotos espacios del cielo, y de distinguir la luz propia dé la luz reflejada, es decir, de reconocer si la luz solar emana de un cuerpo sólido ó de lina envuelta gaseosa" (Humboldt, 1874a, p. 102).

the eighth satellite of Saturn and new appearances of satellites on Uranus, all observed by Lassell using a telescope with an aperture of only 61 cm and a focal length of 6 meters[26].

Even though with today's technologies these tools can be considered outdated, the small lenses revealed a vastness of space that, over time, required new units of measurement to measure spatial distances. When constructing the physical description of the universe, Humboldt still used geographical miles[27], a term currently in disuse for astronomical distances. Today, due to the extraordinary dimensions of space, units such as kilometers per second (KM/S), astronomical units (AU), light years (LY), among others, are preferred[28].

Although today samples can be collected and fieldwork on other celestial bodies can be performed using robotics[29], Humboldt remarks that, in his time, meteorites were the only contact with materials outside our planet. For this reason, he reflects extensively on comets and mentions the historic meteor shower of 1833 as an important factor in the development of theories on electromagnetic phenomena[30]. Humboldt understood that, being an integrated system, the detailed analysis of meteorites found on Earth could reveal significant information about the external and internal space of our planet, including aspects such as the mass and composition of atmospheric elements.

Humboldt's methodological movements promoted a significant dialog with astronomy, which, since the observations of the 17th century, had been consolidating as a modern science after its separation from astrology[31]. Astronomy and geography, aligned with reason, joined forces to develop epistemologies that confronted mysticism and challenged concepts such as the crystal dome that many priests of the Middle Ages claimed existed around the Earth. When the universe came to be interpreted as a branch of the natural sciences, "[...] astronomy, with its daring work, magnifies space indefinitely [...]"[32].

URANOLOGY AND TELLURIC KNOWLEDGE

Enriched by discoveries up until the 19th century, uranology seems to have become an extinct concept in contemporary science. Its disuse may be associated with the decline of positivist currents, since, like cosmography, uranology sought to explain the dynamics of the universe mathematically. Humboldt describes uranology as a knowledge originating from the inexplicable mysteries of outer space, which aroused philosophical ideas and unconsciously elevated thought to a new sphere, allowing the formulation of rationalized and, in his view, higher considerations.

[26] Humboldt (1874b, p. 57-58).
[27] Measurement in geographical miles can be found in all the volumes of the work, for example in Humboldt (1875a, p. 177) or in volume III (Humboldt, 1874b) when he measures the distance between the Earth and Venus on p. 338.
[28] In the 21st century, objects have been identified that are so far away that it would be extremely confusing to use geographical miles. For example, the object UDFj-39546284, which emanates light at 13.2 billion light years from Earth, if represented in geographical miles would result in a numerical combination of 7.759785492602362e+26. Source: Belleville (2022).
[29] In addition to collecting lunar samples on the Apollo missions, China recently collected samples from the 'hidden side' of the Moon during the mission Chang'e 6 (McCarthy, 2024). Perseverance rover has already separated more than 25 samples from the Martian lithosphere, which will be collected in future missions (Bolles, 2024). NASA's OSIRIS-REx mission was also successful in collecting samples from the asteroid Bennu (Canadian Space Agency, 2024).
[30] Humboldt (1874b, p. 41).
[31] The distancing of astronomy from astrology is dated between the end of the 15th century and the course of the 16th century (Almási, 2022).
[32] Translated by Author 1. In the original: [...] la astronomia con sus atrevidos trabajos engrandece indefinidamiente el espacio [...] (Humboldt, 1875a, p. 23).

> In the sidereal or uranological sphere, the problems for everything within reach of observation have an admirable simplicity, and due to the enormous masses and the forces of attraction of matter, they are prone to rigorous calculations, based on the theory of motion. (Humboldt, 1874b, p. 4)[33].

In this sense, for this study, the effort to explain general movements in the exact sciences was partly justified by the impossibility of empirically observing outer space. The physics of cosmic movements brought together the possibility of understanding the "[...] causes with the effects"[34]. This is one of the strongest features of positivism in the Humboldtian idea of the cosmos.

Although positivism found its limits, this does not invalidate the fact that Humboldt pointed in a direction that revealed a dimension of space that inspired and imposed challenges that have been little debated to date. These challenges, however, are likely to resurface with great intensity in the coming years, as investment in outer space projects progressively increases[35].

In the sidereal dimension, Humboldt divides the concept of uranology into two parts: Astrognosy or Sidereal Astronomy, and another part comprising the solar or planetary system. He notes that these definitions are confusing and incomplete, as they arise in the natural sciences "[...] before sufficiently appreciating the true character of their various objects and rigorously limiting them"[36]. At that moment, Humboldt was identifying epistemological challenges that transcended his time and that continue to challenge us today.

Unable to reach the macro-scale directly, Humboldt found in the fluid forms of the earth's surface, particularly in botany, a way of understanding the configuration of landscapes in their broadest sense[37].

> All forms of organic life "animated" plants and animals are the effect of these two ever-divided forces, of which the one, heat, specially appertains to the celestial, and the other, cold, to the terrestrial sphere. (Humboldt, 1874b, p. 16)[38].

However, organic life remains an exclusively terrestrial characteristic. In this context, Humboldt decided to divide telluric knowledge into two departments, unlike what he did when dealing with the uranological sphere, which, as far as we know, is composed only of inorganic dynamics. Thus, the telluric sphere, corresponding to terrestrial space, is defined as follows:

[33] Translated by Author 1. In the original: "En la esfera sideral ó uranológica, los problemas para todo lo que está al alcance de la observación tienen una sencillez admirable, y en razón á las masas enormes v á las fuerzas de atracción de la materia, se prestan á cálculos rigorosos, fundados en la teoría del movimiento" (Humbodt, 1874b, p. 4).

[34] Translated by Author 1. In the original: "[...] las causas com os efectos" (Humboldt, 1874b, p. 7).

[35] According to Linck et al. (2019), NASA alone receives an average annual investment of 25 billion dollars from the US government for outer space exploration. Although we haven't found official figures, Roeloffs (2023) estimates that China, which has emerged as the main competitor to the US in the current space race, invests an average of 22 billion dollars a year..

[36] Translated by the Author 1. In the original: "[...] antes de haber apreciado suficientemente el verdadero carácter de sus diversos objectos, y haberlos limitado de una manera rigorosa" (Humboldt, 1874b, p. 48).

[37] Humboldt (1874a, p. 72).

[38] Translated by Author 1. In the original: "Toda la vida orgánica, las plantas, <<animadas,>> como tambien los animales mismos, son producto de esas fuerzas eternamente opuestas, una de las cuales, el calor, pertence á la esfera celeste, y la otra, el frio, entra en la esfera terrestre" (Humboldt, 1874b, p. 16).

> The telluric sphere as opposed to the uranological, is separable into two portions, namely, the inorganic and the organic departments. The former comprises the size, form, and density of our terrestrial planet, its internal heat; its electro-magnetic activity; the mineral constitution of the earth's crust; the reaction of the interior of the planet on its outer surface which acts dynamically by producing earthquakes, and chemically by rock-forming, and rock-metamorphosing processes; the partial covering of the solid surface by the liquid element - the ocean; the contour and articulation of up heaved earth into continents and islands; and lastly the general external gaseous investment (the atmosphere). The second or organic domain comprises not the individual forms of life which we have considered in the Delineation of Nature, but the relations in space which they bear to the solid and fluid parts of the earth's surface, the geography of plants and animals, and the descent of the races and varieties of man from one common, primary stock. (Humboldt, 1858b, p. 8)[39].

In the dialog between the organic and inorganic departments, Humboldt approached the field of geognosy to demonstrate how telluric studies could reveal the capacity of mathematics to explain space on all its scales. Using formulas that aligned with theories of movement and spatial transformation, Humboldt defined geognosy as "[...] the science of the texture and succession of the terrestrial strata [...]"[40]. The concept is divided into two parts: one mineralogical (or geological) and the other focused on the study of the shape and contour of the continents (geographical). By combining these aspects, a way was found to reconstruct the history of the shape and extent of the continental masses, allowing the telluric sciences not only to explain the present, but also to investigate the past of spatial dynamics. In the second volume, Humboldt also remarks that:

> [...] The greatest of all geognostic phenomena, i.e., the mathematical shape of the Earth, in which the state of the globe in primitive times is clearly reflected, i.e. the fluidity of the mass that has since rotated on itself, and its solidification as a terrestrial spheroid. (Humboldt, 1874a, p. 342)[41].

In this sense, Humboldt argues that the fluidity of the natural dynamics of movement can be described by numerical language, and that complete evidence is only achieved "[...]

[39] Translated by Author 1. In the original: "The telluric sphere as opposed to the uranological, is separable into two portions, namely, the inorganic and the organic departments. The former comprises the size, form, and density of our terrestrial planet, its internal heat; its electro-magnetic activity; the mineral constitution of the earth's crust; the reaction of the interior of the planet on its outer surface which acts dynamically by producing earthquakes, and chemically by rock-forming, and rock-metamorphosing processes; the partial covering of the solid surface by the liquid element - the ocean; the contour and articulation of up heaved earth into continents and islands; and lastly the general external gaseous investment (the atmosphere). The second or organic domain comprises not the individual forms of life which we have considered in the Delineation of Nature, but the relations in space which they bear to the solid and fluid parts of the earth's surface, the geography of plants and animals, and the descent of the races and varieties of man from one common, primary stock" (Humboldt, 1858b, p. 8).

[40] Translated by Author 1. In the original: "[...] the science of the texture and succession of the terrestrial strata [...]" (Humboldt, 1858b, p. 281).

[41] Translated by Author 1. In the original: "[...] el major de todos los fenómenos geognósticos, esto es, el de la forma matemática de la tierra, en la cual se reflejan de una manera patente, el estado del globo en las épocas primitivas, es decir, la fluidez de la masa que desde entonces giraba sobre sí misma , y su solidificación como esferoide terrestre" (Humboldt, 1874a, p. 342).

when it is possible to apply the rigor of reasoning to the general principles of mathematics"[42]. Integrating this approach with physical geography, Humboldt observes that the elements of the earth's inorganic crust are the same as those found in the structures of organisms and plants. He points out that this interconnection is not merely an adaptation, but the manifestation of extensions of the same space. Based on this observation, Humboldt justifies his approach to the Geography of Plants, as they offer ideal conditions for studying terrestrial organic and inorganic phenomena both on Earth and in the sky[43].

In addition to identifying the complementary relationships between the universe and the Earth, the exploration and mapping of the New World and astronomical observations were already advanced in the 19th century, providing Humboldt with a broad view of celestial and terrestrial phenomena. This complemented the old information, which focused mainly on the physical data of the Northern Hemisphere sky. Thus, the horizontal expansion of knowledge broadened the horizons for the vertical expansion of spatial understanding. This new dimension of space not only enriched telluric knowledge, but also deepened uranology. On the geographical horizon of the South, new constellations emerged, which are explored in detail in Chapter VII of the third volume of *Cosmos*[44].

As a result of these profound discoveries, knowledge of the perceptible world expanded and became increasingly complex. The specificities of each discovery divided knowledge to such an extent that, even with the obvious connections, telluric and uranological knowledge became distant again. Perhaps the greatest legacy of Humboldt's notion of the cosmos is that, as geographers, we cannot lose sight of the integration between the macro and micro scales. In the contemporary world, the unfolding of what has been classified as uranological knowledge, coupled with technological development, has expanded the perceptible world to spaces beyond terrestrial limits. This challenges the telluric sciences to interpret spaces that go beyond previously established boundaries, calling into question one of the few consensuses among those who have tried to conceptually define geography as the science of the relationship between humanity and the Earth's surface.

Despite filled with positivist ideas that have been superseded by other currents, Humboldt offers us a basis in geographical traditions that, even if superseded or questioned, cannot be ignored by those seeking new epistemologies for the contemporary world. Although this discourse may sound conservative, this is not our intention. The intention here is simply to reinforce how the foundations of geographical thought are still relevant in the debate on the development and production of knowledge at a time when the world is moving beyond the millennia-old boundaries of geographical thought.

FINAL CONSIDERATIONS

Firstly, Humboldt's cosmos exemplifies what Gomes (2011) called the modern duality, as it is an epistemological movement that confronts the traditions of Antiquity and the Middle Ages with the scientific novelties of the 19th century. This movement, without

[42] Translated byAuthor 1. In the original: "No se llega á una completa evidencia sino cuando es posible aplicar á las lejes generales el rigor del razonamiento matemático" (Humboldt, 1874b, p. 10).
[43] Humboldt (1875a, p. 382-383).
[44] Humboldt (1874b, p. 213).

ignoring the epistemological foundations of science, renews and formulates concepts that help Humboldt expose the specific novelties of that time.

Reflecting upon the methodological bases of the geographical tradition is undoubtedly an exercise that requires the interpretation of discourses permeated by various social and temporal issues. In Humboldt, we find a proposal that seeks universality, evidenced in the concept of Cosmos. Through this concept, the methodology constructed by Humboldt correlates fields of knowledge that encompass geosciences, physics, cosmography and, later, physical astronomy. This integration revealed a more comprehensive world, which simultaneously complemented previously obtained information and posed new challenges.

This study corroborates Bachelard's (1971) assertion that new concepts tend to emerge as new epistemological lenses for understanding what is new in the world in relation to its past. This idea applies perfectly to the case of Humboldt's reframing of the notion of the cosmos to explain the world in the 19th century. Throughout his work he appropriates the concept presented by the Greeks and analyzes it through the sieve of reason, eliminating mythological interpretations without disregarding the original idea of the cosmos as an ontological concept of universal movement.

In addition, Humboldt's cosmos not only indicated the connection between the elements that constitute the perceptible world, but also proposed a methodological framework that offered the possibility of thinking about the space-time relationship in natural history. This method allowed us, through the present, to go back to the past and project the future through the general laws of movement that cover various scales. In other words, guided by reason, the universe and the Earth meet in their multiple dimensions.

As far as geography is concerned, the Humboldtian methodology centers geographical knowledge on the Earth. However, naturalistic descriptions can be observed from an analytical angle that offers this field of knowledge interpretive capabilities for the forms and contents of outer space. Although it centers geography on terrestrial issues, the methodology positions it well to interpret the whole of observable space, as it inverts the scientific tradition of the time, using terrestrial knowledge to explain cosmic dynamics that go beyond the earthly scale.

However, as part of the productivist demands pervading the academic environment, the continuity of telluric and uranographic studies has reached such depths that they have fragmented into new areas and disciplines, further expanding the fragmentation of knowledge and contradicting Humboldt's desire not to lose sight of the cosmos. This phenomenon is evidenced by a quick search in the CAPES database of theses and dissertations, where the combination of the words "Geography" and "Cosmos" results in only 15 results, none of which are directly linked to research on the perceptible universe. This situation leads us to reflect that perhaps Humboldt was one of the first and last to present the world from this perspective.

Therefore, the experience of exploring Humboldt's cosmos in the 21st century reveals that the foundations of modern geographical thinking face persistent challenges, especially in the epistemological impact for geography at a time when the world presents a spatial dimension that goes beyond terrestrial borders. Understanding the past does not offer a complete solution, but it certainly provides a solid foundation of concepts that cannot be ignored when considering the contemporary world.

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