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Decomposing Light into Spectra: Nineteenth-Century Spectroscopy as a Cultural Technique

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Abstract

In addition to its phantasmatic meaning of ectoplasmic presence, the term spectrum refers to a harmonic composition of a variable quantity over time, whose initial field of study was Newtonian optics and the related experiments on visible light. From Newton to the present day, spectroscopic, -graphic, and -metric practices have been established in many scientific areas, ranging from astronomical to chemical and medical studies. Such fecundity cannot be limited to the field of scientific observation alone but also affects numerous other fields of knowledge and culture. Within this stratified tradition, my contribution intends to focus on a decisive historical moment for spectroscopy—the second half of the 19th century—marked by a theoretical and experimental ferment that follows and justifies the production of the first spectroscopic devices, including those of Fraunhofer (1814) and Kirchhoff-Bunsen (1861). Looking at the rich variety of instruments and applications by leading scientific figures such as Wollaston, Brewster, Talbot, and Janssen, one can note the impact that similar researches had on the manufacture of optical equipment, with particular attention to the dialogue with the instances coming from the photographic world. From this discursive and techno-experimental network spectral images seem to assume the role of mediated articulation of the real, in a manner similar to those doors and grids that Bernard Siegert conceives as cultural techniques. In the case of spectroscopy, such technique is structured along an operation of mediation of the gaze that breaks down and recomposes a harmonious subject, the light, in the attempt to bring out from this fractionating process not an augmentation of the visible, but rather the possible cognitive gaps we have on it.

Keywords: Spectroscopy; Cultural Technique; Scientific Photography; Visual Culture; Visual Archaeology.

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1 Decomposing Light into Spectra. Nineteenth-Century Spectroscopy as a Cultural Technique

Nowadays, the study of spectral images is articulated along a stratified series of scopic, metric, and graphic technologies, whose complexity is in turn amplified by the disciplinary and the applicative ramifications that those techniques reveal—from hard sciences such as optics, chemistry, astronomy, or quantum physics to medical and military sciences (Hentschel 2002; Lindon 2010). As broadly demonstrated, the scientific origin of a practice does not prejudice its dissemination in the fields of culture, entertainment, and art, but instead constitutes a historical leitmotif (Crary 1992; Ede 2005); just as, it is worth pointing out, "much of our scientific knowledge actually depends on its representation in visual culture" (Smelik 2010: 10).

This osmotic relationship has attracted growing attention from humanistic studies, in which we are witnessing a wide-ranging "spectral turn" (Blanco, Peeren 2013) but whose origins and directions of research are articulated along diverging trajectories, from studies regarding the role of the spectral image in modern body and medical imaging techniques (Cartwright 1995; Donghi, Toschi 2024) to reflections upon the artistic-cultural nature of color and its components (Horrocks 2012; Pierotti 2012). Furthermore, spectral vision, in particular that which refers to the light ranges invisible to the human eye, has been duly linked to the advent of the post-photographic in contemporary visuality (Grespi, Villa 2024) and to the operational and invisual turning point described by Jussi Parikka, for whom spectroscopy itself would constitute an "alternative history of visual technologies" (Parikka 2023: IX).

While it would be difficult to overestimate the importance of spectral imaging in the contemporary panorama, it is still challenging to decide whether or not to look all the way back to the period of its modern genesis, the 19th century, and in particular the "interregnum" years (Sutton 1974: 43) that span from 1814, when Joseph von Fraunhofer built the first spectroscope, to 1861, with the fundamental discoveries of Gustav Kirchhoff and Richard Bunsen precisely through the use of the spectroscope. This is only the origin of spectral scientific practices, which will assume different forms in the following decades until arriving at the current panorama; nevertheless, these early years constitute a decisive period, especially regarding the consolidation of observational practices and techniques of visualization of the spectral image (Hentschel 2002: 34-44).

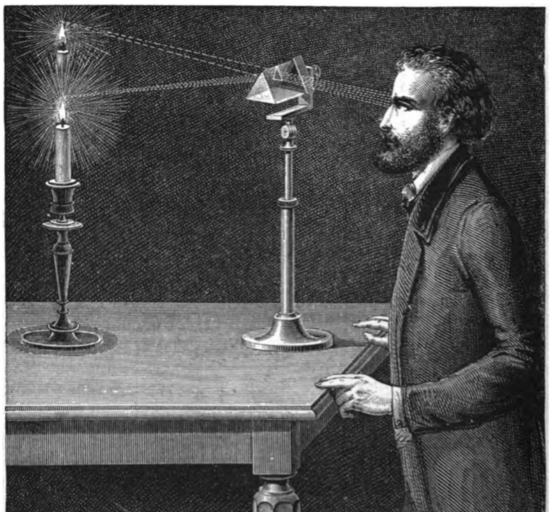

Fig. 1 – A "simple" experiment on the nature of refraction: "Let a triangular piece of glass be held, with a refracting edge at top. between the eye and a lighted candle, it will be found that the candle cannot be seen; but if the prism be gradually raised, the image of the candle will appear, the amount the prism will have to be raised depending on its angle. Now, we have here obtained a deviation or refraction of light" (Lockyer 1873: 10-12).

This essay focuses on the study of the types of spectral analysis used during that era and their impact on the technical and visual culture immediately following, proposing to conceive of spectroscopy as a cultural tech-

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nique, that is, taking up Bernhard Siegert's definition, as an articulation of reality that not only plays a role in strengthening or institutionalizing pre-existing norms but that helps to "destabilize cultural codes, erase signs, and deterritorialize sounds and images" (2015: 15). From this perspective, spectroscopy appears as a practice of dissection of a phenomenon otherwise understood and perceived as cohesive and coherent—light—that activates a profound re-elaboration both on the level of knowledge and of the visual, activating a rethinking of the epistemic relationship between object and image, a relocation of the boundaries between visible and invisible, and a questioning of the role of the human observer between presumed machinic objectivity and interpretation of methods and results.

2 Practices, Discoveries, and Technologies of Early Spectroscopy (1814-1861)

The introduction of the term *spectrum* into the scientific field, as well as the first reflections on the decomposition of light that gave rise to modern optics, can be traced back to Isaac Newton and his experiments with prisms in the second half of the 17th century (Hearnshaw 2014: 15-16). Through the appropriate arrangement of a light source, a circular aperture, a triangular prism, and a screen, Newton was able to observe the transformation of white solar light into a colored beam that went from a red extreme to a violet extreme and thus intuited how sunlight is composed of a set of rays with different refractive properties. He therefore gave the new image of decomposed sunlight the name of *spectrum*, etymologically "appearance" and "apparition" precisely to underline the intrinsic visual quality of this epiphany (Shamey, Kuehni 2020: 99-106).

The groundbreaking Newtonian observations were followed by a long period of relative stasis in terms of studies on the spectral image, that stasis was broken only at the beginning of the 19th century when a series of technological innovations, experimental intuitions, and improvements in imaging systems gave rise to "unusually productive [years]" (Hearnshaw 2014: 16). A first, fundamental impulse came from the Englishman William Wollaston, who, in 1802, modified the Newtonian device by replacing the circular aperture with a linear slit, an adjustment that allowed him to obtain a much sharper spectral image, to the point that he was the first to notice the presence of black lines, parallel to each other, which interrupted the chromatic flow transversally according to a distribution that Wollaston was unable to explain.

Fig. 2 – Postage stamp commemorating the 200th birthday of Joseph von Fraunhofer (1787-1826) (© Deutsche Bundespost). The image takes the original Fraunhofer nomenclature of the main black lines in alphabetical order (A to H), from the red area down to the violet one.

It was precisely by focusing on these mysterious black lines that, in the 1810s, the Bavarian Joseph von Fraunhofer developed an instrument aimed at exponentially improving the optical possibilities of spectral analysis.

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The instrument, which he called *spectroscope*, updated Wollaston's system by placing a convex lens between the slit and the prism and integrating the spectral observation with a telescope (Lockyer 1873). Through the spectroscope, Fraunhofer obtained a more stable and defined image, from which he was able to identify around 574 lines, labeling the most relevant ones with a letter of the alphabet from A to H. It was also with a spectroscope that Fraunhofer observed the spectrum of other stars, noting how the arrangement of the lines in each of them changed, effectively making each spectral image a *unicum* recognizable for that specific light distribution.

With the commercialization of the Fraunhofer spectroscope, which was quickly followed by many new models, the empirical investigation of spectral images and their composition became one of the most widespread and significant scientific research activities of the following decades. A surprising number of astronomers, opticians, and chemists devoted themselves to it assiduously, investigating not only celestial and natural light sources but also terrestrial and artificial ones: from William Talbot to Léon Foucault, from David Brewster to Michael Faraday, a dense international network was thus created in the name of both collaboration and competition in working towards discoveries in what appeared to be one of the most promising new science frontiers (Hearnshaw 2014: 21-25).

Among others, worthy of mention is the Englishman John Herschel, who already in 1800 had given spectral analysis a decisive impetus with the discovery of the infrared region of the electromagnetic spectrum, revealing the non-coincidence between the humanly visible limit of light and the actual range of light sources and paving the way for the branch of studies on the "edges of the rainbow" (Richards 2011: XXII-XXIII). Later, in 1882, when he was studying the visible spectrum of colored flames, Herschel conceived a fundamental idea that gave further stimulus and prestige to the spectroscopic method: any element present in a flame is clearly visible on its spectrum, regardless of the quantity in which it is present. Spectroscopy thus proved a useful practice not only for the study of extremely distant objects, such as celestial bodies, but also for the identification of extremely minute quantities of elements, which are not traceable in the object of analysis (Sutton 1974).

In the wake of these and other observations, around 1860, Gustav Kirchhoff, in collaboration with Robert Bunsen, was able to explain the presence and distribution of black lines, now called Fraunhofer lines, applying the principles of absorption and emission of light: according to their postulate, the interruptions in the spectrum would be caused by the presence of cold gases in the external part of the atmosphere of the celestial body, which, when the light passes through them, absorb the corresponding portion of the spectrum emitted by the same gas present inside the celestial body (Hearnshaw 2014: 26-32).

Based on this fundamental intuition and with the awareness that specific lines refer to unique atoms and molecules, spectroscopy became a tool for the detection of elements present in the atmosphere of celestial bodies and, consequently, also led to the discovery of new ones. Kirchhoff and Bunsen themselves identified two new elements in 1861, cesium and rubidium. A few years later, Pierre Janssen observed a total solar eclipse via spectroscope, reporting the presence of new yellow lines on the solar spectrum; following this lead, Norman Lockyer and Edward Frankland isolated the element and gave it the name *helium*: "Thus, with the aid of spectroscopy an element had been discovered in another part of the solar system before being detected on earth" (Thomas 1991: 631).

As observed by the science historian Klaus Hentschel, in a fundamental volume dedicated to the topic, 19th century spectroscopy, although never assuming the traits of a distinct discipline, had a profound impact on the scientific and visual culture of the time. In particular, according to Hentschel, it contributed to the spread of a "puzzle solving" approach to natural phenomena, whose distinctive features were the use of standardized experimental methods, the presence of heuristically strong phenomenological rules that govern expectations, the detection of anomalies that disappoint these expectations, and the transmission of highly specialized skills (Hentschel 2002: 424).

It is therefore not surprising to note how, in parallel with the proliferation of experiments and methodological developments in spectroscopy, we witness the fabrication and marketing of updated and specialized spectroscopic devices, a sign of rising demand for the improvement of instruments and for a refinement of the available range according to uses that now widely diverged from each other. The manuals of the time leave clear traces of this trend. For example, take the booklet published by John Browning (1878), a well-known

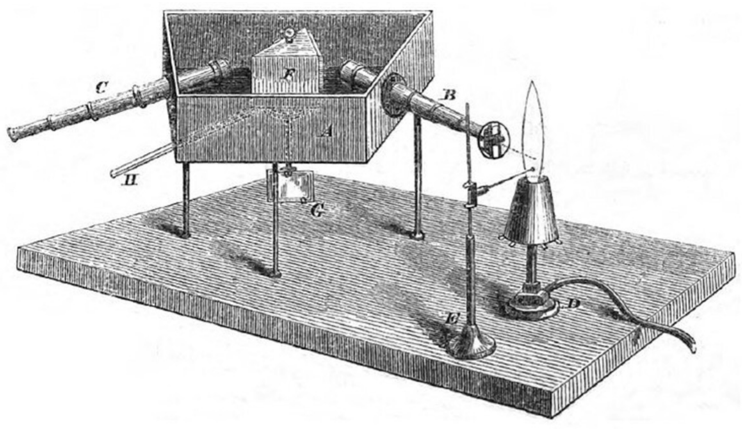

Fig. 3 – Kirchhoff and Bunsen's Spectrometer (Chemical Analysis by Spectrum-observations 1860: 91).

English manufacturer of scientific instruments, which not only listed the dozens of spectroscopes available on the market at that time, but also gave instructions on when and how to use them. This booklet discusses both professional and amateur usages for educational or recreational purposes, for chemical or physical studies, and it takes into account distinctions based on the objects of study, the technical skills of the operator, and the user's spending capacity. A multifaceted selection that Browning considers and to which he contrasts his personal model of spectroscope, strategically presented as universal and automatic, since it can be used by everyone and is "applicable to every class of spectrum work either in the laboratory or observatory" (Browning 1878: 13). Such technological range shows that, already from the second half of the 19^{th} century, spectroscopy was not "just" a scientific practice, in which an elite community was interested, but had the characteristics of an optical industry with evident links to various other techno-industrial applications.

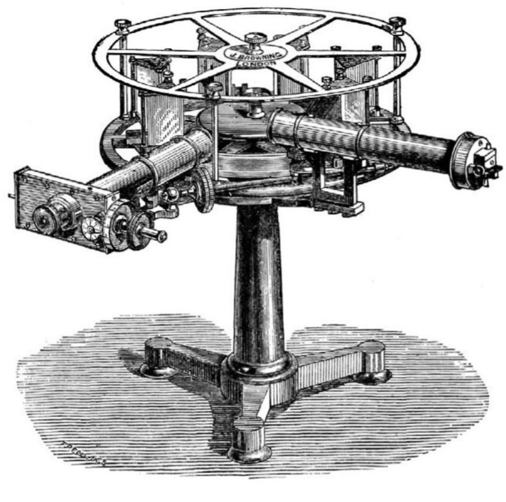

Fig. 4 – "Browning's Universal Automatic Spectroscope" (Browning 1878: 12). According to description, although the device is the "most complex ever made," it is very easy to use because the mechanism for regulating the prisms is no longer the responsibility of the observer but of the instrument itself, which in the junction of the six prisms with the telescope adjusts the vision.

3 Spectroscopy's Connections with Other Optical and Photo-Chemical Fields

The potential of spectroscopy within and outside of scientific research did not escape contemporaries, who repeatedly emphasized how these decades constituted nothing but "the infancy" of spectroscopy (Lockyer 1873: 1). The embryonic dimension, however, does not only refer to the scientific potential for discoveries in the aforementioned physics and chemistry but also to its applications in other fields of technology, culture, and knowledge, some of which had already been delineated in the second half of the 19^{th} century (Linley, Colligan 2011).

First of all, we must not forget the importance spectroscopy had in the development of the optical industry on an international scale. Fraunhofer not only gave it a scientific boost with his publications but also stimulated support for the Bavarian optical industry, initiating competition with the hitherto dominant English one (Brenni 2017). In particular, the challenge of making improvements in the production of achromatic lenses, a fundamental aspect of spectroscopy, constituted the main "technological battle" of that period (Sutton 1974: 52) and inevitably ended up involving other optical technologies that, more or less in the same era, were rapidly becoming established: photography, telescopy, stereoscopy, and periscopy, just to name a few.

Spectroscopy, in particular, had a close relationship with photography, with the two techniques being presented as "twin sciences" (Woods 1888: 1), essentially complementary to each other, and not infrequently with scholars switching from one to the other, as the correspondence between Herschel and Talbot in the 1840s attests (Sutton 1974: 56). In other words, both the use of spectroscopy in photography and the use of photography in spectroscopy were mainly prompted by the need to fill their respective gaps and overcome the limitations that the single techniques still seemed to present.

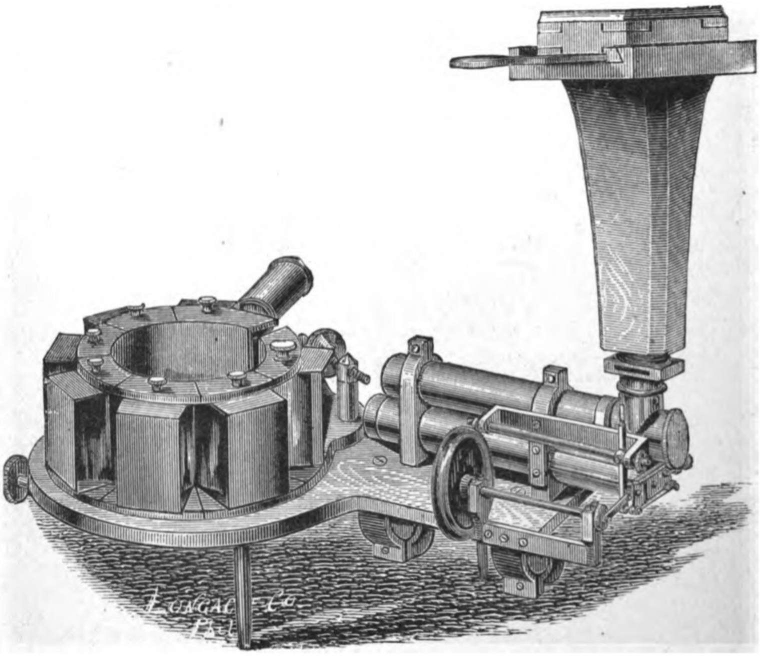

Fig. 5 – "Sun Spectroscope arranged for photography" (Lockyer 1873: 62).

The second half of the 19th century was marked by the progressive and persistent use of photography in spectroscopic experimentation. From Henry Draper to Carl Vogel to Henri Becquerel, empirical investigations of spectral images advanced by means of contemporaneous photographic techniques (Hentschel 2022). The advantage offered by the photographic medium for spectral analysis is, in this sense, twofold. First, it allows an expansion of the visible spectral range, since the sensitivity of the mechanical photochemical process does not coincide with the sensitivity of our eye, allowing us to visualize a larger portion of the spectrum (Draper

1875: 265). Second, as is typical for the adoption of photography in the scientific method, a perceived increase in "objectivity" in the process; photography would be "so much more trustworthy than human vision" (Woods 1885: 1) since it crystallizes the spectral image, allowing for repetitive scrutiny and the prevention of possible divergences. Nonetheless, rather than representing a substitute for direct human vision, photography was primarily conceived as a support to it since "the chemical action of the spectrum on a photographic plate was *minimal* precisely in those areas of the spectrum where the eye gauged at *maximum* intensity" (Hentschel 2022: 66).[1]

Similar observations can also be found in the opposite direction, that is, by looking at the use of spectroscopy in the field of photography. As underlined in *The Spectroscope and Its Relation to Photography* by C. Ray Woods (1885), knowing the fundamentals of spectroscopy and being able to read a spectral image constitutes an added value for any photographer who wishes to obtain "faithful" images, where fidelity essentially means the understanding of the photo-chemical variables that can influence the image during the development and printing phases (Woods 1885: 27-45).

These applications would find a moment of particular importance in the years between the 19th and 20th centuries, with Gabriel Lippmann's studies on scientific color photography and the introduction of the interferometric method, crowned with the Nobel Prize for Physics in 1908. In the wake of previous observations on the use of the spectroscope in the theory of colors,[2] Lippmann carried out a study that was fascinating from a scientific, cultural, and artistic point of view, which represented an important step in turning "the science-oriented part of 'serious' photography into a new discipline of scientific photography alongside the already existing subdisciplines of photochemistry, physical optics and optical technology" (Hentschel 2022: 80). Similar reflections are also found in Robert William Wood's contemporary research in the field of infrared photography, whose images, according to the author, would have a true epiphanic value in that they would show how "we do not see things as they are" (1910: 336) and which also offer not so much a view of body temperature as "the world's capacity to transmit—reflect, deflect, or absorb—infrared rays" (Starosielski 2021: 171).

Finally, it is worth emphasizing that spectroscopy was not only linked to photographic practices and color studies but also played a significant role in the field of artificial light source production, an industry that was in great ferment in those years (Bernal 1953: 113-133). In this case, too, it was a double and reciprocal gain process. Double in that, for spectroscopy, improvements in projective technologies guaranteed greater control and versatility in terms of its object of analysis, namely light, and decreed the limits within which it was possible to project the spectral image without excessively modifying it; reciprocal in that the production of photographic devices itself was able to take advantage of a system of control over its products and of a demand that would prove constant over the following decades. Therefore, catalogues such as Browning's also include a large section dedicated to describing the range of lamps available on the market as well as detailed instructions on "how to show spectra on screen" (Browning 1878: 37-39).

1. Italics in the original.

2. See, for examples, the experiments of Hermann von Helmoltz (Shamey, Kuehni 2020: 173-196).

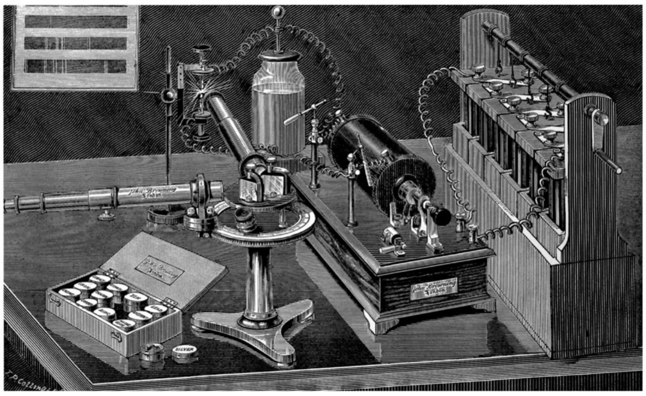

Fig. 6 – “Spectrum apparatus in action, showing the spectra of metals” (Browning 1878). On the lower right is a box containing various metals for burning the sample flame, and on the upper right are spectra with different compositions depending on the type of blaze observed.

4 Spectroscopy as a Cultural Technique of Decomposing Reality

As observed by Hentschel, the extension of 19th century spectroscopy’s fields of application came at the price of “a lack of disciplinary coherence” (Hentschel 2002: 422), further accentuated by the natural predisposition for practical experimentation according to descriptive and phenomenological methods and rarely burdened by broad-ranging theoretical interpretations, which did not promote it to an autonomous science but relegated it to an ancillary role as part of the historically more established disciplines. Even in those cases where the formation of societies dedicated to spectroscopy initially formed, new names were later adopted. For example, the Società degli Spettroscopisti Italiani, which was founded in 1871 and focused on the fundamental task of the study and daily drawing of “protuberances and their spectra [the stars]” (Naccari 1897: 670), was later renamed Società Astronomica Italiana in 1920.

Questioning the correct method of historically and culturally framing spectroscopy in the face of such disciplinary incoherence, Hentschel integrates his scientific perspective with some of the most well-known observations from the field of visual studies, mainly from the Anglo-Saxon milieu. In doing so, spectroscopists become first and foremost “people [that] were especially suited to transfer specific visual skills into the natural sciences and hence [that] were instrumental in creating visual science-cultures” (Hentschel 2002: 431). They were intermediaries for the circulation of specific scientific knowledge, of a strongly empirical culture, and of precise spectrum visualization techniques, creating localized “scopic domains” where the concept of “domain” constitutes a reinterpretation, toned down and extended, of that of a “scopic regime,” as defined by Martin Jay (1988).

If Hentschel’s fascinating interpretation of 19th century spectroscopy is particularly effective in giving a coherent form to such an undisciplined phenomenon, without homologating its differences but rather seeing them as derivations of a common technical, methodological, and visual background, its medial dimension—that is, the set of practices and technologies that establish the epistemic relationships between the observer, the object, and its image—remains cut off. In this sense, a perspective complementary to that of Hentschel would look at spectroscopy as a *cultural technique* that articulates reality and at the spectral image as the object in which this articulation is grasped.

Reflections on cultural techniques have been the focus of several investigations, especially a decade ago, when a number of contributions questioned their meaning and suitability in the broader spectrum of media studies beginning with, but not limited to, a discussion of Friedrich Kittler’s complex work and the long tradition, mainly in the German arena, of the use of the term (Siegert 2007, Winthrop-Young 2013). Specifically, in this context, by cultural techniques I mean the “operative chains that precede the media concepts they generate” (Siegert 2015: 11), which are designed for a multicultural perspective (not one but more techniques) and which differ from technologies because of their intrinsic symbolic work of articulating reality (Macho 2013). Understood in this way, spectroscopy becomes fundamentally a technique through which an apparently coherent and cohesive phenomenon—light—is transformed into an image that, like a fingerprint, is its truthful and yet unrecognizable trace, and which, precisely because of that, calls into question its referential status.

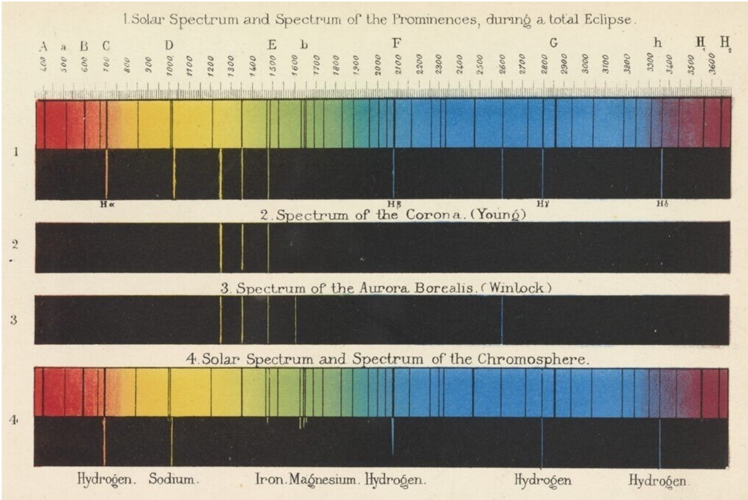

Fig. 7 – Examples of spectra taken of the sun and the aurora borealis (Schellen 1872). The four spectra show the permanence of Fraunhofer's visual model, although now applied according to a comparative scheme.

From a more strictly visual point of view, the spectral image has established itself as a radically different apparition compared to the normal way of seeing light (with the sole exception of the rainbow, obviously). Nonetheless, in its novelty, the spectral image has also crystallized in the years between Wollaston, Herschel, and Fraunhofer into a rather schematic and solid graphic model; a representative standard that is still widely used today: a linear trace, characterized by a chromatic flow that opens on the left with the infrared and ends on the right with the ultraviolet and which is interrupted by the presence of parallel black lines at varying intervals (Roscoe 1873).[3] In looking at the stability of this iconographic model, Hentschel retrieves from Ernst Gombrich (1969) his observations on the importance of didactic practices to underline how spectroscopy constitutes an emblematic case of the stabilization of visual models to simplify the operations of orientation through and sharing of the collected data (Hentschel 2002: 440-441).

The first, decisive gap that spectroscopy triggers is related to the image as a tool for scientific investigation. Where traditionally it has value as a representation of reality, with spectral analysis the image becomes a source of knowledge that is autonomous to its object. In commenting on the discoveries of Kirchhoff and Bunsen, Foucault enthusiastically stated: "Che importa che il Sole disti da noi 150 milioni di km., se i raggi della sua luce conservano i segni caratteristici delle sostanze che lo costituiscono?" (Naccari 1897: 670). The identification of elements such as sodium in the solar spectrum or the discovery of new elements is based on a methodology that, as Fraunhofer had already intuited, no longer addressed the study of a phenomenon through direct testing but, as observed by Susan Schuppli, "by treating it as an image" (2020: 278). Schuppli herself, in her study on material witnesses, looks recursively at the spectral image as an exemplification of "nonhuman entities and machinic ecologies that archive their complex interactions with the world, producing ontological transformations and informatic dispositions that can be forensically decoded and reassembled back into a history" (Schuppli 2020: 3). A forensic reading that also validates the initial observation on the epistemic autonomy of the spectral image.

This detachment of the image from its referent is articulated not only along the axis of the physical distance between the observer and the scopic object but also in the relationship between the effective quantity of an element within that object and its visibility on the spectrum. As already indicated, a turning point for spectroscopy was the understanding that analysis "enables us to detect the minutest trace of the constituents

3. This is not the only representational or scopic model of spectral images, but just the main representational one in vogue in those years. For a comparison, see Hentschel (2002: 80-110).

of substances burnt" (Draper 1866: 17). This confirmed another intuition of Fraunhofer, linked to the previous one, that is, that the essence of an object could even be determined by the aesthetic judgment provided by chemical analysis alone; in other words, recognizing "the primacy of the visual in deliberating truth claims" (Schuppli 2020: 278). This reworking of the relationship between objects and images finds echoes in other scientific fields that proposed a similar shift in meaning in relating to the images produced by new techniques. As observed by Linda Bertelli (2018: 189), even the physiology of the time was marked by a new epistemic principle according to which the function of an organ no longer depends on its shape but on a conception of the body as a visible surface on which invisible forces act.

The element of rupture with a representative tradition in spectroscopy made it a technique particularly dear to members of the 20th century artistic avant-garde who saw in the spectral image an effective scientific reference to describe their desire to break with the accepted visual paradigm of the time. Consider, for example, the reference to Fraunhofer lines in the manifesto *Du Cubisme* by Albert Gleizes and Jean Metzinger (1912), which Linda Henderson proposes "are signs of the invisible and confirm that reality is more complex than positivist science or Impressionist and Neo-impressionist painting had discerned" (1988: 335). There are no shortage of literary references either. In his investigation of the mutual influence of photography and modern art in the twentieth century, Michael North dedicates a chapter to Francis Scott Fitzgerald's *The Great Gatsby* and to the use, within the novel, of the concept of "spectroscopic gaiety" (North 2005: 109-139). Adopted to describe how the inhabitants of East Egg looked at and therefore labeled the lives of their neighbors in West Egg, the adjective *spectroscopic* highlights the mechanical and artificial nature of the characters' looking, an act that is not only mediated by a series of social and cultural factors but which produces an image that is fundamentally different from the usual one: "A view of its subject that doesn't correspond to unaided visual experience at all" (North 2005: 122).

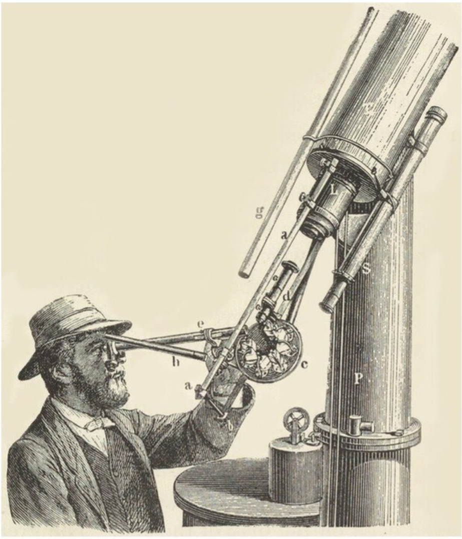

Fig. 8 – Illustration of Norman Lockyer using a telespectroscope (Scheller 1872).

In its positioning as autonomous and radically different from its referent, the spectral image also shifts attention to the never-ending question of the boundaries between visible and invisible and the meanings attributed to the two polarities (Sorlin 1977). From Herschel's discoveries to the late 20th century emergence of X-ray vision techniques and their applications in the medical and entertainment fields, the spectral image has been one of the most effective examples in re-evaluating the limits of direct scientific observation of natural phenomena (Richards 2011). In this sense, the disproportion between the naked-eye range of the spectrum and its real scope has had a double consequence: "da una parte, venire a patti con un invisibile che ci è stato a lungo precluso [...] e che può finalmente assumere una consistenza visiva; dall'altra, trasformare l'apparenza di ciò che ci è sempre parso consueto, imparando a re-incontrarlo in modo straordinario" (Donghi, Toschi 2024: 41).

The "alien" quality of the spectral image finds its reflection once again in the literary field, where several authors of early science fiction, and, in particular, Camille Flammarion, have introduced speculations on the possibility of life forms other than terrestrial ones precisely because they were "influenced by developments in photography and spectroscopy" (Matheson 2013: 87). This is evident not just in science fiction but in horror too. In his volume dedicated to the study of the electromagnetic spectrum in imaging technologies, not coincidentally entitled *Alien Vision*, Austin Richards opens with two passages taken from the genre of horror fiction, inevitably drawing attention to the double meaning of the term—admonition and display—and to the dialectic it establishes with the spectral image (Richards 2011: XIX-XXIII). Particularly telling is the passage taken from *The Damned Thing*, written by Ambrose Bierce in 1893:

> At each end of the solar spectrum the chemist can detect the presence of what are known as "actinic" rays. They represent colors—integral colors in the composition of light—which we are unable to discern. The human eye is an imperfect instrument; its range is but a few octaves of the real "chromatic scale." I am not mad; there are colors that we cannot see. And, God help me! The Damned thing is of such a color (Bierce, in Richards 2011: XIX)!

The crisis in the relationship between image and object, the problematization of the visible and invisible polarities, and, finally, the re-elaboration of the role assumed by human observation—both in terms of scopic limits and capacities, and with respect to the criteria of objectivity and judgment—as underlined by Peter Galison, are always historically contextualized and dialectically in tension with each other (2013: 327-359). The fickleness of human observation regarding the spectral image is underlined by 19th century spectroscopists themselves on several occasions: "The eye is not always the same. [...] The colour sensation caused by a particular ray cannot, therefore, be relied upon to furnish more than a general indication of its position" (Woods 1885: 16). But the limit of the human eye is not only in its susceptibility to contingent stimuli but also in terms of sensitivity: "True, the eye is not delicate enough to distinguish between the tints of two lines lying very close together" (Woods 1885: 32). Hence the aforementioned attention to the possibilities of the photographic medium aligning with the fragilities of human vision, but to which, as has already been said, rather than being a substitute, it became complementary.

A similar ambivalence links spectroscopy to other scientific practices of the time, with which it ends up creating a sort of technical and methodological arsenal to be wielded whenever one wants to push beyond the limits of human vision. Think in this sense of the attempt to combine spectroscopy with early scientific cinematography, carried out by the Catalan astronomer Josep Comas i Solà in the early twentieth century. In the analysis made by Francesco Giarrusso, spectroscopic cinematography would have had the effect of dramatically separating the body of the observer from his organ of sight, human or artificial, since "nothing of what we see will ever be within our sight's reach" (Giarrusso 2015: 39).

But let's also look at the field of chronophotography, another practice that shares many points of contact with spectroscopy. In fact, both can be read as practices aimed at the decomposition of reality, which differ in their object of study: movement for the first and light for the second. Even in chronophotographic experiments, we easily find different instances similar to the ones observed for spectroscopy: an image that becomes somehow autonomous from its referent, also giving rise to visual revelations (such as the famous case of Muybridge's horse); an apparently coherent phenomenon (the passage of time) that is now crystallized and translated into a visual form that, as in the case of Marey's graphicism, abandons its recognizability (Marey 1878; Bertelli 2018). Indeed, even Georges Didi-Huberman's well-known observation on Marey's work as a "danse de toute chose" (Didi-Huberman 2004) seems to focus on the same mechanism of distortion of the visible observed in spectroscopy: a universal relationship that underlies other decisive aspects, such as the distance, the elusiveness and the minimalism of the phenomenon, and that triggers a backwards effect putting the observer, the phenomenon, and the image back in contact with each other again.

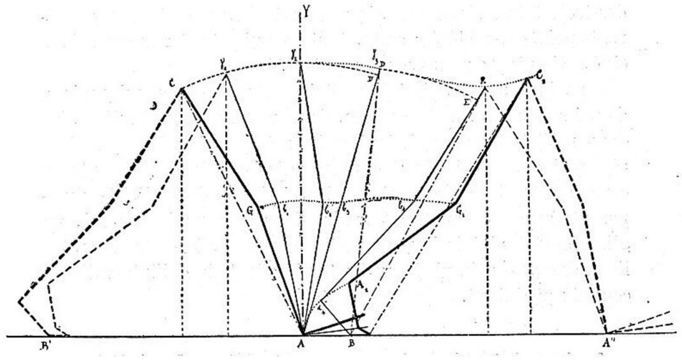

Fig. 9 – Marey's graphic method (Marey 1878). The dynamism of the leg is reduced to a graphic topology from which the decomposition of movement into salient points/moments emerges.

5 Conclusions

As Parikka notes in his reading of Siegert's work, "cultural techniques scholars articulate materialities as historically changing sets of practices" (2013: 153). In this light, the research on spectroscopy conducted here invokes precisely the clash between ever-changing practices, both in the field of application and the object of study, and forms of resistance, foremost among them the representational model of spectra. Among the most interesting results of this collision is the emergence of a redefinition of the visibility of the materials involved. From this perspective, in fact, we are not only witnessing a new way of visualizing light, but also the optical properties of spectroscopic instruments, from lenses to screens, which, as previously shown, must now meet new precise standards that represent necessary conditions for scientific practice.

Simultaneously, a comparison between spectroscopy and other apparently related practices is not intended to convey their meanings, effectively flattening the discourse on spectroscopy as a cultural technique, but rather to try to place it within a composite panorama of techniques and technologies that, operating in the interstices between different disciplines, discourses, and institutions, have profoundly affected the status of the image both in relation to its phenomenal referent and to the observer. To return to Hentschel's observations one last time, whether one looks at spectroscopy as a constellation of visual domains or whether one understands it as a cultural technique, the idea of a "contested terrain" (Hentschel 2002: 435) in continuous metamorphosis remains valid, giving rise at the same time to dynamics that are both constructive—the establishment of new forms of scientific knowledge, of scopic techniques, and representative models—and destructive—the recurring crisis of the polarities image/object, visible/invisible, human/machinic, judgment/objectivity.

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