Gender analysis on the Ph.D. theses defended in Spain in the field of Optics and Photonics

Rosa Ana Pérez-Herrera
Department of Electrical Electronic and Communication Engineering
Public University of Navarra
Pamplona, Spain
rosa.perez@unavarra.es

María-Baralida Tomás
Instituto Universitario de Física Aplicada a las Ciencias y las Tecnologías, Universidad de Alicante
Alicante, Spain
maria.baralida@ua.es

Beatriz Santamaría
GOFB-CTB, Dpto. Ing. Química, Mecánica y Diseño Industrial, ETSIDI
Universidad Politécnica de Madrid
Madrid, Spain
betxu.santamaria@upm.es

Alba de las Heras
Departamento de Física Aplicada, Universidad de Salamanca
Salamanca, Spain
albadelasheras@usal.es

Clara Benedi-Garcia
Instituto de Óptica, Consejo Superior de Investigaciones Científicas
Madrid, Spain
c.benedi@csic.es

Ana I. Gómez-Varela
Departamento de Física Aplicada, Instituto de Materiais
Univ. de Santiago de Compostela
Santiago de Compostela, Spain
anaisabel.gomez@usc.es

Martina Delgado-Pinar
Departamento de Física Aplicada
Universitat de València
Valencia, Spain
martina.delgado@uv.es

Verónica González-Fernández
Dpto. De Óptica
Universidad Complutense de Madrid
Madrid, Spain
veronicagf@ucm.es

***Abstract*—Unconscious perceptions and decisions are influenced by gender bias. In this work, we provide an exhaustive data analysis of the Ph.D. theses defended in the field of optics and photonics in Spain by filtering key descriptors and gender. Our results show a severe underrepresentation of women in the Ph.D. stage in the optics community, which becomes even more prominent in technological and theoretical domains. The gender gap is reduced in biomedical and visual optics. This asymmetry is a symptom of gender bias in science associated with traditional stereotypes about health and social care. Further studies and measures are required in specific areas of science to eradicate implicit gender-based associations in scientific disciplines.**

Keywords—gender bias, gender gap, optics, photonics, Ph.D., women in science.

I. INTRODUCTION

In recent years, the academic community turned its eyes to wonder why the majority of scientists are heterosexual, white men from developed countries. The lack of diversity in the academy is a fact, and a call to open science to people with different profiles, origins and, hence, ideas, is considered as an urgent requirement. We focus this work on the particular case of women in Spain who have obtained their doctoral degree in optics and photonics related fields.

Gender stereotypes play a fundamental role in determining the social role of men and women and, in the worst cases, generate discrimination and inequality. Some of these stereotypes associate greater intellectual ability (brilliance, genius, etc.) with men more than with women. This is part of a biased system and is a transversal feature through all the areas, but it becomes more important in science, technology, engineering, and math (STEM) [1]-[3]. The gender stereotypes discourage women from pursuing certain types of careers traditionally considered more demanding, both in educational and professional contexts. According to a study published in 2017 [4], the effects of such stereotypes appear in boys and girls as young as 6 years old, influencing their interests. Specifically, 6-year-old girls are less likely to think that people of the same gender are "brilliant". At this same age, girls begin to avoid activities more recognized as to be done by those who are "really smart". However, at the age of 5, both boys and girls associated intelligence with their own gender in equal parts. This study suggests that concepts such as the genius of a person are acquired early and will end up influencing the decisions of girls when it comes to certain activities, in particular the STEM-related ones.

A typical situation of gender unbalance in the academic community occurs every year when the Nobel prizes are awarded. The gender gap in the female representation when it comes to the recognition of the work of female scientists (not only Nobel prizes) is clear. To go further in this example, the Nobel has recognized 887 men and 58 women, whereas the latter corresponds to 25 women in scientific categories and 34 in literature and peace. Although the presence of women in these awards has increased in recent years - between 1902 and 1921 only 4.1% of the winners were women, while that figure was 12.4% between 2002 and 2021 - there is still a long way to go [5], [6]. Although gender bias is most likely not the only one involved, the gender ratio of the awardees is clearly symptomatic of the gender gap in the Nobel prizes.

There is always a try to explain the ratios in Nobel prizes as a consequence of the high standards that these awards require. Others justify it because women have traditionally occupied much fewer positions than men have in academia. However, this lack of equal representation of men and women is not an anecdote in this type of awards usually granted to scientists with a mature career, but it extends through the

whole academic career. Even in those areas with a majority of women in undergraduate or postgraduate studies, at some point in the development of their careers, there is an exchange between the percentages of men and women holding the relevant positions.

The last survey by the Equality Committee of the National Council for Research in Spain (Consejo Superior de Investigaciones Científicas, CSIC) shows that the famous "scissor"-trend between the percentages of men and women at different stages of their scientific career has its turning point (i.e. the age at which the percentage of men overpass the percentage of women) earlier in the academic career [7]. While in 2016 this turning point appeared at some point in the postdoctoral stage, in 2019 the scissor turned into a tweezer: women do not even begin a Ph.D. Hence, the biased situation does not seem to compensate, but the contrary. Another evidence supporting this observation is that, according to the data provided from the Universities, in technology-related areas, the number of theses published by men is three times the ones defended by women, in the period 2007-2016 [8].

As mentioned, the gender bias is transversal through all the areas, but its importance increases in those closer to physics, engineering and computer science [1], [9]-[11]. In particular, in our field of interest, optics and photonics, it can be observed in a variety of situations as well. While the areas related to biomedicine, biotechnology and vision are more attractive to women, they still are underrepresented by women. The gender gap is even bigger in other areas such as nonlinear optics, quantum optics or optoelectronics where full research groups are formed by men, and there is a really scarce number of female researchers. As an example, if we take into account the data of the associates to SEDOPTICA, the National Spanish Society for Optics and Photonics, for the year 2021 the percentage of women is 21% in the Optoelectronics Committee, 18% in Quantum Optics and Nonlinear Optics Committee, while 36% in Visual Sciences Committee [12]. The origin of this asymmetry may lay in traditional stereotypes of health and social care, which have been typically more related to women, whereas the other more technical and theoretical fields have been historically more male-dominated. It is important to note that Photonics has been identified as a Key Enabling Technology in the Horizon2020 plan of the UE and the Spanish Plan Estatal de Investigación Científica y Técnica y de Innovación 2017-2020, which points out that this area should receive special attention (section 6.3.3 in the mentioned plan). This attention should not only be addressed to funding, but also to human resources prioritizing a true incorporation of women in relevant positions within this area.

Thus, it is a fact that (1) some areas are less attractive for women, even within the same research field such as optics and photonics and, (2) the number of women who decide to pursue an academic career in those areas is decreasing in the last few years. Apart from other reasons that may include the lack of opportunities for young researchers (both male and female), there is a gender point of view to be considered. In this context, the Women in Optics and Photonics Committee of SEDOPTICA initiated a quantitative study with a gender perspective to show the situation in figures. Up to our knowledge, this project is pioneer in the analysis of gender statistics within the optics and photonics community. The objective of this work is to show the first results of this data analysis, which consists of the quantification of Ph.D. theses defended in optics and photonics in the period 2015-2020 and the disaggregation of these data in terms of gender and specific UNESCO codes. We identify implicit gender-based associations to particular areas of optics and photonics. In our view, the presentation of the data helps to make the problem more visible, and opens the path to apply new policies to compensate for this systematic bias.

II. SUBJECT OF THE STUDY

A. *Theses repository TESEO*

The Spanish Ministry of Education has an open database collecting the information of all the theses published in Spain since 1976. This database name is TESEO [13]. No matter the subject of the thesis or the university where the work has been done, every single thesis is registered in the repository. Therefore, it is an excellent opportunity to have access to the theses regarding optics and photonics since the 70s.

To classify the theses, each user has the option of choosing up to four keywords for their work. It is possible to search all the theses defended in a temporal frame, by defining the topics of the work done. Those keywords are classified using the UNESCO nomenclature for fields of science and technology, which is an international standard nomenclature used for the classification of research papers and doctoral dissertations.

B. *Optics and Photonics*

Many of the existing studies choose large areas of science (physics, chemistry, mathematics, and engineering) as their objects of study. We focused our efforts on a subtopic within physics, namely into the fields of optics and photonics. It is a very interesting area as an object of study, since it also covers the area of optometry, leaving purely technical areas. Additionally, optics is such a transverse wide field that it spans over several disparate topics like astronomy, imaging, life science, chemistry, quantum physics or nanotechnology, to cite a few.

Several Spanish universities offer Ph.D. programs centered in optics, but usually, they are focused on visual optics and optometry. On the other hand, there are no Ph.D. programs that assemble the whole variety of fields in optics and photonics, as they are often dispersed in physics, chemistry or engineering programs.

III. METHODOLOGY

A custom database was elaborated with information extracted from the TESEO repository [13]. The theses of interest in this study were those related with the field of optics and photonics and defended during the years 2015 to 2020, from all Spanish universities, both public and private. The theses were filtered according to the UNESCO codes and the Ph.D. graduation year. Descriptors were selected following the universal UNESCO codes that classify the different areas of knowledge. The following parameters were completed in the custom database: code and name of descriptor, surname, and name of the thesis author, the title of the thesis, university, department, year, Ph.D. program, kind of the thesis (clinical-bio or technical-fundamental optics), number of members in the tribunal and number of women within the tribunal. The gender of the doctoral student was assumed from their first name in the TESEO database, as a

consequence we could not consider non-binary gender in this study.

To perform this study we have chosen 83 keywords present at the TESEO database regarding optics and photonics, all of them corresponding to UNESCO codes. In total more than 4200 results have been carefully studied and classified attending to the technical or clinical character. Note that a particular thesis could have more than one UNESCO code studied here, so it would be in more than one analysis shown later. Nevertheless, it is not a disadvantage as we are analyzing the women's and men's theses in each UNESCO nomenclature and not all in combination.

IV. Results

The following figures show the results obtained in this study. Each of them depicts the percentage of theses, separated by women (purple color) and men (orange color), and published in Spain from 2015 to 2020 in both public and private universities. To get a better visualization of the results, we have divided the 83 UNESCO codes into groups of 8-11, trying to assemble in each figure similar descriptors. In every graph below, we analyze the percentage of theses defended by men and women for each descriptor.

Fig. 1 shows the bar chart, differentiating between women (purple) and men (orange) for the first 10 UNESCO codes belonging to categories 21 (astronomy and astrophysics) and 22 (physics). As it can be seen in this figure, the percentages correspond to the codes of category 21: X-ray sources, optical astronomy, positional astronomy, telescopes, astrophysical spectroscopy, and category 22: electromagnetic waves, gamma rays, infrared, visible and ultraviolet radiation, interaction of electromagnetic waves with matter and X-rays in that order. Only one of the results obtained (in particular, the one related to the UNESCO code of positional astronomy) shows an even distribution, where 50% of the theses defended within this topic were written by women. In the rest of the cases and as it will be seen in the rest of the study, the distribution is far from balanced, reaching some deviations of more than 30% from the average.

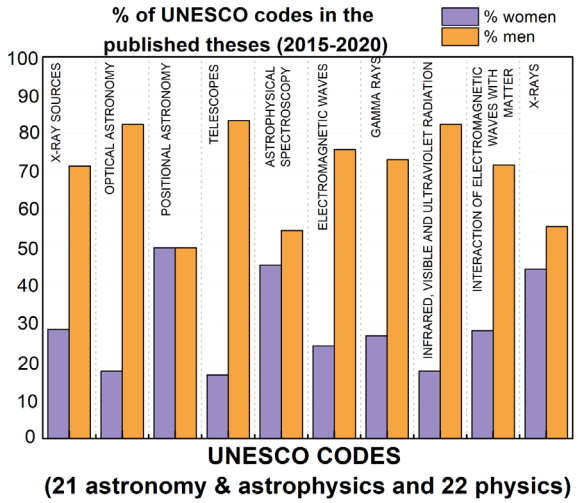

Fig. 1. Bar chart, differentiating between women (purple) and men (orange) for 10 UNESCO codes belonging to category 21 (astronomy and astrophysics) and 22 (physics).

The following four figures, from Fig. 2 to 5, show the bar chart, again differentiating between women (purple) and men (orange), for the 40 UNESCO codes belonging to the physics category, in which optics is included. It is important to note that among all of them, only 7 out of the 40 UNESCO codes reach or come close to parity between women and men. As a remarkable example, the fact that women outnumber men in optometry (see Fig. 3) confirms the importance of stereotype roles in the success of women along their careers. It is also worth noting the existence of disparate gender differences in Figs. 2 and 3, where the UNESCO codes laser molecular spectroscopy, beam sources and photographic instruments have been included only in theses written by men. Moreover, in the physics category, we can point out that women are more underrepresented in descriptors associated with fundamental theoretical physics like nonlinear optics (Fig. 3), or light-matter interactions (Fig. 1).

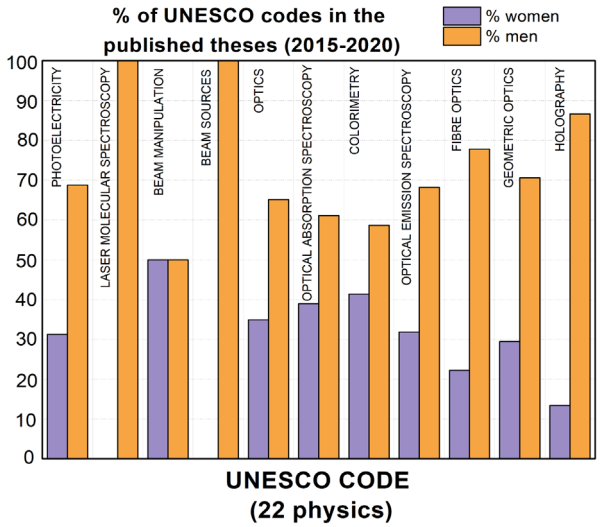

Fig. 2. Bar chart, differentiating between woman (purple) and men (orange) for 11 UNESCO codes belonging to category 22 (physics).

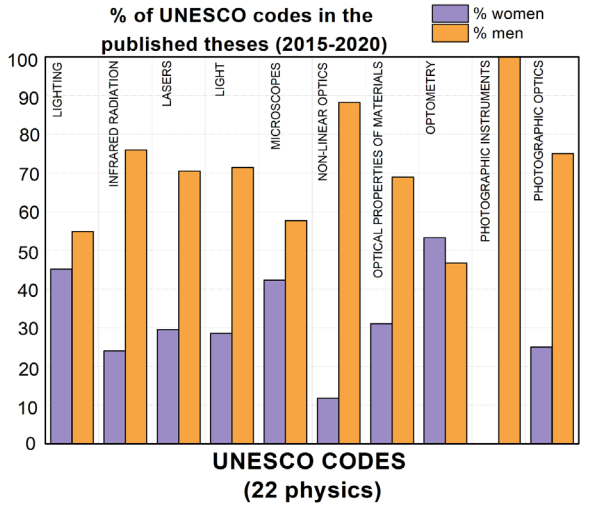

Fig. 3. Bar chart, differentiating between women (purple) and men (orange) for 10 UNESCO codes belonging to category 22 (physics).

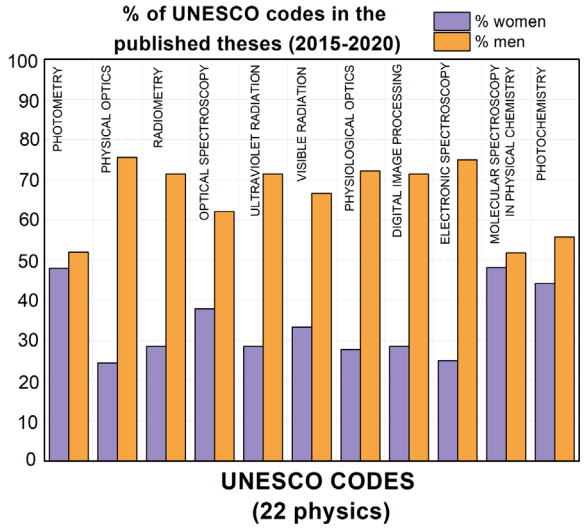

Fig. 4. Bar chart, differentiating between women (purple) and men (orange) for 11 UNESCO codes belonging to category 22 (physics).

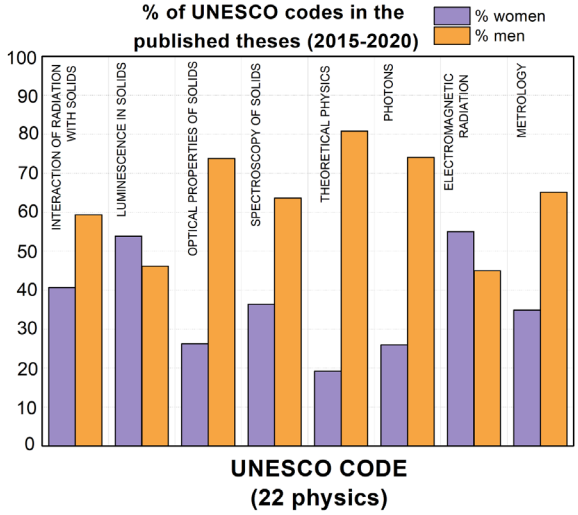

Fig. 5. Bar chart, differentiating between women (purple) and men (orange) for 8 UNESCO codes belonging to category 22 (physics).

Fig. 6 shows the distribution of percentages between women (purple) and men (orange) for 11 UNESCO codes, which are relative to category 23, chemistry. The presence of women in the case of chemistry is more representative than that of physics. Even still, the percentage of men is high in categories such as optical microscopy (diff 25.37%) or microwave spectroscopy (diff of 23.08%). The statistics are very similar between both genders in 5 out of the 11 codes (differences of percentage between women and men lower than 16%). Remarkably, the number of women overtakes that of men in the UNESCO codes of fluorimetry, mass spectroscopy, phosphorimetry and x-ray spectroscopy, with a mean difference between women and men of 36.7%.

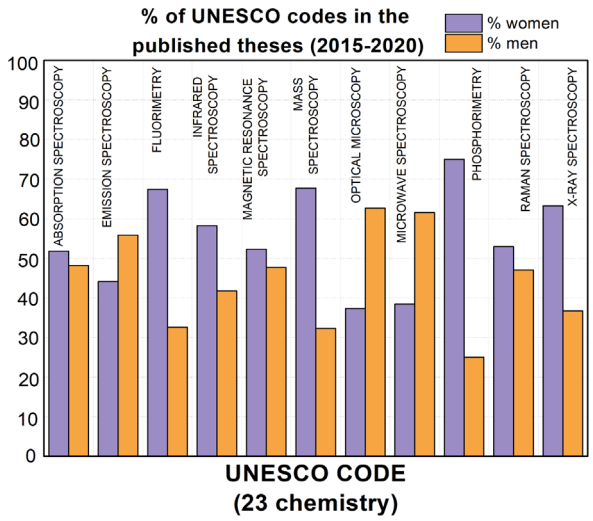

Fig. 6. Bar chart, differentiating between women (purple) and men (orange) for 11 UNESCO codes belonging to category 23 (chemistry).

In Fig. 7, the percentages of theses defended by women (purple) and men (orange) are represented for UNESCO codes belonging to categories 24, 25, and 32, with the names of life sciences, earth and space science, and medical science respectively. The distribution of women and men for the codes belonging to group 24 was unequal, with a higher presence of women in the bio-optics category (diff of 20%) and of men in the physiology of vision category (diff of 26.83%). The presence of men in the group of earth and space science is considerably bigger than the presence of women, with differences between both genders over 70%. Women and men equitably defended their theses with the codes belonging to group 32, with a difference of percentage lower to 17% between them.

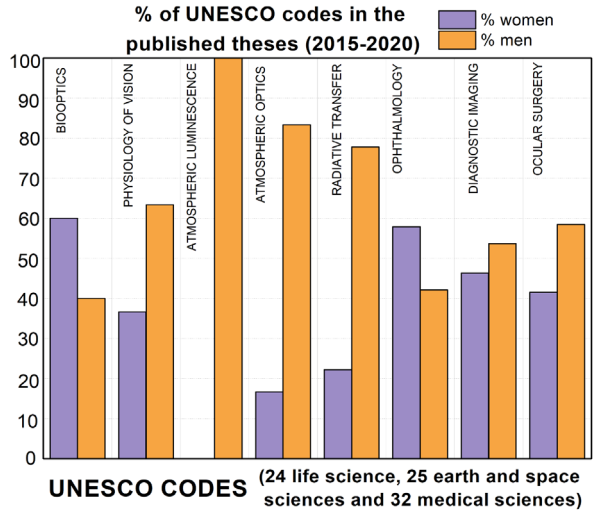

Fig. 7. Bar chart, differentiating between women (purple) and men (orange) for, from left to right, 2 UNESCO codes belonging to category 24 (life science), 3 UNESCO codes belonging to category 25 (earth and space sciences) and 3 UNESCO codes belonging to 32 (medical science).

Finally, Fig. 8 shows one of the most striking case studies carried out during the preparation of this work. This figure shows the percentage of theses defended by women (purple) or men (orange) in which UNESCO code 33 (technological sciences) was included. When evaluating these results, we

can see that in all the UNESCO codes studied, the percentage of theses defended by women that include this category (purple) is notably lower than those defended by men (orange). Worth mentioning are the cases of the UNESCO codes electro-optical devices, where this difference exceeds 85% (7.14% women and 92.86% men) or fiber optic communications, with a difference between percentages of more than 68% (15.79% women and 84.21% men).

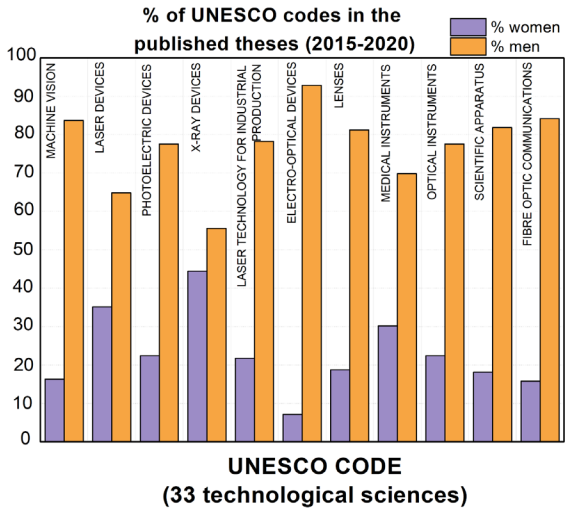

Fig. 8. Bar chart, differentiating between women (purple) and men (orange) for 11 UNESCO codes belonging to category 33 (technological sciences).

V. CONCLUSIONS

As a summary, in this work we present a quantitative study of the theses defended within the area of optics and photonics in Spanish universities in the period 2015-2020, by disaggregating the data in terms of gender and key descriptors. The data was collected from the TESEO database, which does not explicitly specify the gender of the theses' authors, thus gender was deducted from the author's first name. For the whole data collection, the global percentage of descriptors chosen by women is 37.5% (see Fig. 9). This data reveals that this number is far from the 50% of women in predoctoral studies that the CSIC survey for the year 2020 reports [5], which includes all the research areas. Hence, the optics and photonics field presents a systematic bias that deserves special attention and analysis.

To perform a detailed study of the Ph.D. stage, we used 83 UNESCO codes to classify the theses and organize them in subtopics related with optics and photonics. The percentage of women and men for each code was calculated and presented in the form of chart bars. It is a general result that the percentage of women is far from equal in most cases of UNESCO code 22, physics, except a few of them such as: beam manipulation, lighting, optometry, photometry, molecular spectroscopy in physical chemistry, luminescence in solids, or electromagnetic radiation. In particular, in optometry the percentage of women overpasses men, confirming the importance of stereotype roles. On the other cases, it is difficult to draw firm conclusions, for different reasons: well there is a scarce number of thesis included in the descriptor, well the descriptor covers such a broad area of knowledge that might include theses of other subtopics (see Supplementary Material section for total numbers of theses in each descriptor). It is also worth noting that there are some topics where there is no representation of women at all (laser molecular spectroscopy, beam sources, photographic instruments, atmospheric luminescence), although the scarce number of theses within these topics might be the reason for this issue.

In the case of photometry, molecular spectroscopy in physical chemistry or photochemistry, the percentage of women is close to 50% even with a significant total number of theses. These topics are highly related to chemistry degrees, where the bias of women vs. men is not as relevant as in physics. This is also visible in the results depicted for the code 23 (Fig. 6), which includes the topics related to chemistry. As a summary, regarding the physics category, the results show a certain gender asymmetry between applied and fundamental physics, having this last one less women representation.

Finally, for UNESCO code 24 (Fig. 7) those areas related to life sciences and ophthalmology present a majority of women, again supporting the hypothesis of the stereotype roles on the selection of a thesis topic. On the other extreme, areas more related to technological sciences (UNESCO code 33, see Fig. 8) such as electro-optical devices and fiber-optic communications suffer from women underrepresentation, with all the bias and problems this implies for the perspectives of these fields for the near future.

From the analysis of these data, it is clear, in our opinion, that active policies to improve equality in optics and photonics should be applied from the very beginning in the academic career. Further investigation with a particular focus on unconscious gender-based associations to specific scientific areas is needed. Our work paves the way to extend similar data analysis to other scientific communities and disciplines, but also to other stages of the scientific career.

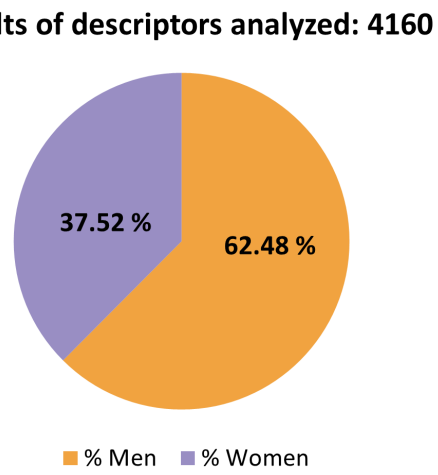

Fig. 9. Pie chart representing the results of all the UNESCO codes chosen by women and men analyzed in this study.

VI. PERSPECTIVES

In this preliminary work, we focused our efforts on a study that analyzes the gender of people who defended a thesis in the last 5 years in Spain in the field of optics and photonics.

However, the TESEO database includes more information such as the Ph.D. program, the composition of the jury, etc. Therefore, the data compiled in TESEO is worthy of a more ambitious analysis including, for example,

if aspects such as the nature of the Ph.D. program (including its name, for example, since it has resulted to be relevant for other degrees, such as computer science vs. computer engineering, when taking into account the number of women carrying out these studies), influences the number of women who enroll in them.

Also, the workgroup that has performed this study has collected data for the progress of women in the academic career, collecting and analyzing the data of women granted by postdoctoral programs or achieving a stable position in academia, in order to show the own *leaky pipeline* of women in optics and photonics. It is well known that factors such as maternity and labor precariousness (inherent to scientific careers in Spain) affect women more than men, and that they are more evident in the postdoctoral stage. Thus, since in this field there is a bias from its very beginning in the predoctoral stage, it will be interesting to analyze if this effect amplifies here more rapidly than in other areas. This topic is currently a work in progress for the Workgroup.

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REFERENCES

[1] J. R. Cimpian, T. H. Kim, and Z. T. McDermott, "Understanding persistent gender gaps in STEM," Science, vol. 368, no. 6497, pp. 1317–1319, June 2020.

[2] C. Tomassini, "Gender Gaps in Science: Systematic Review of the Main Explanations and the Research Agenda," Education in the Knowledge Society, vol. 22, p. Article e25437, 2021.

[3] A. García-Holgado, S. Verdugo-Castro, C. S. González, M. C. Sánchez-Gómez, and F. J. García-Peñalvo, "European Proposals to Work in the Gender Gap in STEM: A Systematic Analysis," IEEE Revista Iberoamericana de Tecnologías del Aprendizaje, vol. 15, no. 3, pp. 215-224, 2020.

[4] L. Bian, S. J. Leslie, and A. Cimpian, "Gender stereotypes about intellectual ability emerge early and influence children's interests," Science, vol. 355, no. 6323, pp. 389–391, January 2017.

[5] P. Lunnemann, M. H. Jensen, and L. Jauffred, "Gender bias in Nobel prizes," Palgrave Communications 2019 5:1, vol. 5, no. 1, pp. 1–4, May 2019.

[6] L. I. Meho, "The gender gap in highly prestigious international research awards, 2001–2020," Quantitative Science Studies, vol. 2, no. 3, pp. 976–989, November 2021.

[7] Consejo Superior de Investigaciones Científicas, "Informe anual 2020." 2020. [Online]. https://www.csic.es/es/el-csic/ciencia-en-igualdad/mujeres-y-ciencia/documentos (accessed Decembre. 10, 2021).

[8] E. Hernández-Martín, F. Calle, J. C. Dueñas, M. Holgado, and A. Gómez-Pérez, "Participation of women in doctorate, research, innovation, and management activities at Universidad Politécnica de Madrid: analysis of the decade 2006-2016," Scientometrics, vol. 120, pp. 1059–1089, July 2019.

[9] Grupo especializado de mujeres en física de la Real Sociedad Española de Física, "Las físicas en cifras: Universidad," 2021. [Online]. Available: http://www.gemf-rsef.es/wp-content/uploads/2021/11/Informe-Mujeres-PDI-Fi%CC%81sica.pdf (accessed Decembre. 10, 2021).

[10] R. A. Perez-Herrera et al., "SEDOPTICA-MOF: fomentando la igualdad de género," Reunión Nacional de Óptica, Madrid, November 2021 [13th National Optical Meeting, RNO, Spain].

[11] Directorate-General for Research and Innovation Horizon 2020 Science with and for Society, She Figures - Gender in Research and Innovation Statistics and Indicators. Brussels: European Commission, 2021.

[12] C. Botella, S. Rueda, E. López-Iñesta, and P. Marzal, "Gender Diversity in STEM Disciplines: A Multiple Factor Problem," Entropy 2019, Vol. 21, Page 30, vol. 21, no. 1, p. 30, January 2019.

[13] Ministerio de Educación, Cultura y Deporte. Gobierno de España., "Teseo." [Online]. https://www.educacion.gob.es/teseo/irGestionarConsulta.do (accessed Dec. 11, 2021).

SUPPLEMENTARY MATERIAL

TABLE I. LIST OF ALL THE DESCRIPTORS ANALYZED DIVIDED BY THE SAME CATEGORIES THAN IN FIGURES 1-8, WITH THE TOTAL NUMBER OF THESES IDENTIFIED WITH THE DESCRIPTOR, NUMBER OF WOMEN AUTHORS AND PERCENTAGE THAT THEY REPRESENT.

	UNESCO Code	Descriptor name	Total theses	Women	% Women
21 ASTRONOMY AND ASTROPHYSICS 22 PHYSICS	210115	X-RAY SOURCES	14	4	28,57%
	210300	OPTICAL ASTRONOMY	17	3	17,65%
	210301	POSITIONAL ASTRONOMY	4	2	50,00%
	210302	TELESCOPES	18	3	16,67%
	210303	ASTROPHYSICAL SPECTROSCOPY	55	25	45,45%
	220204	ELECTROMAGNETIC WAVES	33	8	24,24%
	220205	GAMMA RAYS	26	7	26,92%
	220206	INFRARED, VISIBLE AND ULTRAVIOLET RADIATION	17	3	17,65%
	220207	INTERACTION OF ELECTROMAGNETIC WAVES WITH MATTER	61	17	27,87%
	220212	X-RAYS	36	16	44,44%
22 PHYSICS	220308	PHOTOELECTRICITY	32	10	31,25%
	220611	LASER MOLECULAR SPECTROSCOPY	4	0	0,00%
	220801	BEAM MANIPULATION	4	2	50,00%
	220802	BEAM SOURCES	2	0	0,00%
	220900	OPTICS	166	58	34,94%
	220901	OPTICAL ABSORPTION SPECTROSCOPY	18	7	38,89%
	220903	COLORIMETRY	29	12	41,38%
	220904	OPTICAL EMISSION SPECTROSCOPY	22	7	31,82%
	220905	FIBER OPTICS	63	14	22,22%
	220906	GEOMETRIC OPTICS	17	5	29,41%
	220907	HOLOGRAPHY	15	2	13,33%
22 PHYSICS	220908	LIGHTING	31	14	45,16%
	220909	INFRARED RADIATION	25	6	24,00%
	220910	LASERS	132	39	29,55%
	220911	LIGHT	21	6	28,57%
	220912	MICROSCOPES	26	11	42,31%
	220913	NON-LINEAR OPTICS	68	8	11,76%
	220914	OPTICAL PROPERTIES OF MATERIALS	116	36	31,03%
	220915	OPTOMETRY	92	49	53,26%
	220916	PHOTOGRAPHIC INSTRUMENTS	1	0	0,00%
	220917	PHOTOGRAPHIC OPTICS	4	1	25,00%
22 PHYSICS	220918	PHOTOMETRY	25	12	48,00%
	220919	PHYSICAL OPTICS	86	21	24,42%
	220920	RADIOMETRY	14	4	28,57%
	220921	OPTICAL SPECTROSCOPY	66	25	37,88%
	220922	ULTRAVIOLET RADIATION	28	8	28,57%
	220923	VISIBLE RADIATION	15	5	33,33%
	220924	PHYSIOLOGICAL OPTICS	36	10	27,78%
	220925	DIGITAL IMAGE PROCESSING	224	64	28,57%

	221007	ELECTRONIC SPECTROSCOPY	12	3	25,00%
	221020	MOLECULAR SPECTROSCOPY IN PHYSICAL CHEMISTRY	27	13	48,15%
	221022	PHOTOCHEMISTRY	122	54	44,26%
22 PHYSICS	221113	INTERACTION OF RADIATION WITH SOLIDS	32	13	40,63%
	221116	LUMINESCENCE IN SOLIDS	26	14	53,85%
	221124	OPTICAL PROPERTIES OF SOLIDS	42	11	26,19%
	221132	SPECTROSCOPY OF SOLIDS	11	4	36,36%
	221200	THEORETICAL PHYSICS	151	29	19,21%
	221211	PHOTONS	27	7	25,93%
	221213	ELECTROMAGNETIC RADIATION	20	11	55,00%
	221402	METROLOGY	43	15	34,88%
23 CHEMISTRY	230101	ABSORPTION SPECTROSCOPY	54	28	51,85%
	230105	EMISSION SPECTROSCOPY	34	15	44,12%
	230106	FLUORIMETRY	43	29	67,44%
	230108	INFRARED SPECTROSCOPY	67	39	58,21%
	230109	MAGNETIC RESONANCE SPECTROSCOPY	65	34	52,31%
	230110	MASS SPECTROSCOPY	124	84	67,74%
	230112	OPTICAL MICROSCOPY	67	25	37,31%
	230113	MICROWAVE SPECTROSCOPY	13	5	38,46%
	230114	PHOSPHORIMETRY	4	3	75,00%
	230117	RAMAN SPECTROSCOPY	68	36	52,94%
	230120	X-RAY SPECTROSCOPY	49	31	63,27%
24 LIFE SCIENCES 25 EARTH & SPACE SCIENCES 32 MEDICAL SCIENCES	240605	BIOOPTICS	25	15	60,00%
	241115	PHYSIOLOGY OF VISION	41	15	36,59%
	250102	ATMOSPHERIC LUMINESCENCE	1	0	0,00%
	250108	ATMOSPHERIC OPTICS	12	2	16,67%
	250123	RADIATIVE TRANSFER	9	2	22,22%
	320109	OPHTHALMOLOGY	437	253	57,89%
	320115	DIAGNOSTIC IMAGING	177	82	46,33%
	321309	OCULAR SURGERY	77	32	41,56%
33 TECHNOLOGICAL SCIENCES	330420	MACHINE VISION	190	31	16,32%
	330707	LASER DEVICES	54	19	35,19%
	330709	PHOTOELECTRIC DEVICES	49	11	22,45%
	330723	X-RAY DEVICES	9	4	44,44%
	331008	LASER TECHNOLOGY FOR INDUSTRIAL PRODUCTION	23	5	21,74%
	331104	ELECTRO-OPTICAL DEVICES	28	2	7,14%
	331109	LENSES	16	3	18,75%
	331110	MEDICAL INSTRUMENTS	63	19	30,16%
	331111	OPTICAL INSTRUMENTS	49	11	22,45%
	331113	SCIENTIFIC APPARATUS	22	4	18,18%
	332511	FIBER OPTIC COMMUNICATIONS	38	6	15,79%