

## BALKAN COUNTRIES PRESENCE IN SCIENCE CITATION INDEX AND SCOPUS IN THE FIELDS OF PHYSICS AND CHEMISTRY

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*Abstract.* We examine the research output from the Balkan Countries in the fields of physics and chemistry registered in the databases of Science Citation Index and SCOPUS for the years 1996-2010. Over the years, the relative contribution from the area has increased on average by approximately 50% and represents around 4% of the world overall production. However, the diversity of the Balkan region is also reflected in the performance of individual countries. Although each of them shows growth in the last decade in absolute terms, relative downturn is evident in several cases. Data are provided about cooperation among Balkan countries.

*Key words:* Physics and chemistry publications, Balkan Countries, scientometrics.

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### 1. INTRODUCTION

Scientific research relies very much on publications of results published in the past. We have only to remember the words of Sir Isaac Newton: “If I have seen further, it is by standing on the shoulder of giants”. A book, dedicated to Lomonosov [1] provides a glimpse of the practices in the middle of XVIII century for science abstracting and indexing, where about dozen pages document short presentations of papers authored by Lomonosov and printed in various Western European journals. In the last century, in the fields of physics and chemistry prominent places were held by the publications of *Physics Abstracts* and *Chemical Abstracts* which appeared for the first time, respectively in 1898 and 1907, both of them providing essential information for more than hundred thousand papers published annually in the recent decades. Many countries, in particular those most advanced scientifically, had their own system for abstracting and indexing of scientific papers.

A major change took place in 1960 with the establishment of *Institute of Scientific Information* in Philadelphia and its *Science Citation Index*, both initiated by

Eugene Garfield [2]. This was the beginning of a creation of database providing information about citation of scientific papers. This feature gives a possibility for the researcher to find out in which subsequent publications a given paper has been quoted and how the ideas of the primary source evolved. The index now collects data from around 10000 most prominent journals published in the World, containing the most significant additions to scientific knowledge. The database is extremely rich, it includes papers published after 1900 in all scientific fields, and separately for Social Sciences, Arts and Humanities, contains data about millions of chemical compounds and information for much more patents. Information is located through key-words, authors name or their affiliation. The beginning was in paper form publication presented in dozens annual volumes in very small print, later CD version followed and now all the information is accessible through Internet to subscribing institutions. Additional information about the product can be obtained from the web-site of the current owner of the database [3], which is now known as *Web of Science*.

At the beginning the intentions behind the new index were to provide information to the researcher, but later a whole new field of scientometrics begun to develop studying data included in the index. Using the database it is possible to follow how a given scientific subject evolves in time. One can trace the development of a scientific institution or laboratory, and detect the appearance of new branch of science or a field that is becoming exhausted. The number of citations and ranking of scientists on the basis of bibliometric indicators have been used to provide assessments of individuals as a basis for appointments, advancements in position or reaching a decision for funding of projects. Such practice has been viewed as inappropriate by the community of scientists as evidenced by the recent statement of the European Physical Society [4]. References on similar reactions can be found therein. A preference is given to a balanced peer review from specialists in the given field of science, instead of judgements on the basis of crude numeric data only.

SCOPUS is another database which provides similar information. It was established more recently and is owned by *Elsevier* [5]. Its base is wider in number of scanned journals, nearly twenty thousand titles, including non-peer-review journals. Both databases include documents from conferences. Another source with similar resources, perhaps including widest spectrum of information, is provided by GOOGLE search engine under the name *Google Scholar*. The latter source is freely available through Internet.

The quantitative analysis of research has been widely applied to compare performance of research in different countries [6]. The observations are useful for planning of science, for making decisions on funding of projects and institutions, and for comparing the developments of scientific activities in our competing world. Our aim is to examine the rate of scientific publications in the fields of physics and chemistry by authors affiliated to institutions in the Balkan countries. To our knowledge such

data have not been published previously. In addition we provide data about scientific cooperation among Balkan countries through joint publications. The area was affected by high degree of instability in the last two decades when wars were fought, new countries were born, one federal state was destroyed and the whole structure and tissue of all societies underwent fundamental changes. This is reflected in the obtained data.

## 2. DATA COLLECTION

In our study we have included the following countries: Albania (AL), Bosnia and Herzegovina (BA), Bulgaria (BG), Croatia (HR), Cyprus (CY), Greece (GR), Macedonia (MK), Moldova (MD), Montenegro (MN), Romania (RO), Serbia (SR), Slovenia (SI), Turkey (TR) and Yugoslavia (YU). Cyprus and Moldova are brought in for cultural reasons. Their national physics societies are members of the Balkan Physical Union (BPU), organization of national societies of physicists from Balkan countries established in 1985. This is not the case for all Balkan countries. Data is collected from the databases of Science Citation Index (SCI) and SCOPUS (SCO). The collected data represent papers published during 15 years, 1996-2010. The data are grouped for three five year periods, to reduce fluctuations which are more pronounced when presenting data on annual basis. Only papers published in journals and conference proceedings were taken into account, while other forms of publications, for example abstracts, were disregarded. The collection of data (SCO) was done in the first half of October 2011 at our home university where at the time this database was accessible, while the other set of data (SCI) was obtained in the first half of March and on June 14, 2012 at the University of Niš in Serbia.

Each database has its own classification of scientific subjects. Physics and chemistry being closely related sciences have some of their common boundaries blurred and not defined in unique way. For example crystallography is sometimes classified as a field within physics, but sometimes could be on the other side of the border as branch of chemistry. In a small country such shift can change the predominance in terms of publications of one department over another, and give higher weight to one field versus the other. In taking data from both databases, we were looking for papers in the fields of physics or chemistry as they are represented in the corresponding databases. The more detailed subdivisions of each field are ignored.

There are other types of errors which are present in the data obtained. They result from double or multiple counting of single paper which has authors from two or more countries. It appears that the current literature disregards this question, because it is considered as insignificant in numbers [7]. Minor number of attribution of authors to another country can be spotted occasionally, but this should be certainly

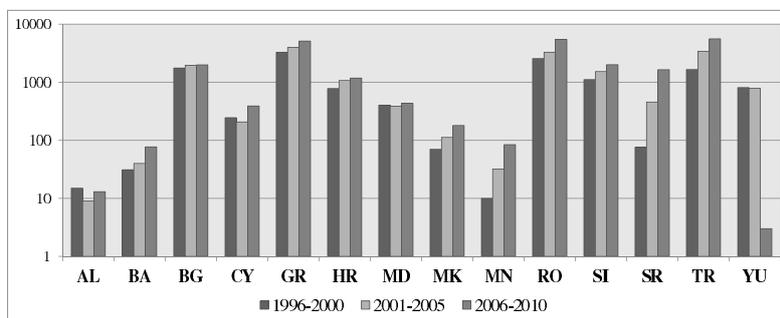


Fig. 1 – Physics publications from Balkan countries for three consecutive five-year intervals: 1996-2000, 2001-2005 and 2006-2010. Data obtained from Science Citation Index.

without importance. Another factor is more important and it is related to the political restructuring of the area and redistribution of data from the past to the newly established state entities. For this reason part of the data appear not to have been settled definitely.

### 3. RESULTS

Our findings are represented in graphical form. In Figs. 1 and 2 the number of physics and chemistry publications registered in the SCI database is shown. For each country in both scientific fields, three adjacent vertical bars in different grey shades represent the number of publications in three consecutive five-year intervals, 1996-2000, 2001-2005 and 2006-2010. In physics (Fig. 1) with the exception of three countries all the others have increasing number of publications in each pair of succeeding intervals. Similarly, in chemistry (Fig. 2) there is only one exception, all other countries show continuous growth in the number of publications. In the last five-year interval the largest number of papers in physics comes from Turkey (5567), Romania (5484) and Greece (5104). The corresponding numbers for publications in chemistry are: Turkey (8350), Romania (4825) and Greece (4527).

Analogous data obtained from the SCOPUS database are presented in Figs. 3 and 4. For both physics and chemistry, there are only two countries which do not show continuous growth, although for the interval 2006-2010 scientists from each country have increased the number of their publications. There is only one change in the ordering of top three countries. In physics the highest number of publications comes from Turkey (11034), Greece (8520) and Romania (8453), while in chemistry the ordering is unchanged: Turkey (9811), Romania (5365) and Greece (4996).

The following set of four figures represent the same data as in the previous figures but shown in a different perspective, illustrating the relative contribution of

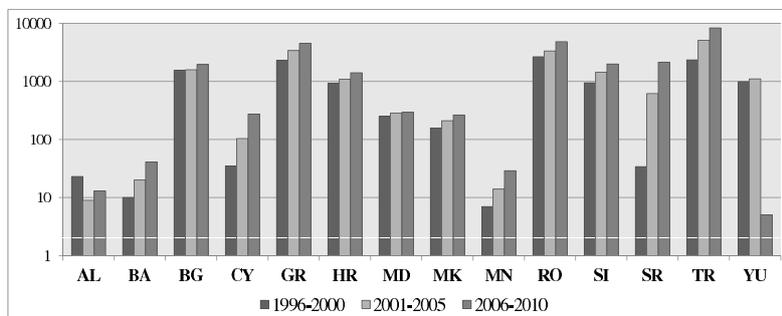


Fig. 2 – Chemistry publications from Balkan countries for three consecutive five-year intervals: 1996-2000, 2001-2005 and 2006-2010. Data obtained from Science Citation Index.

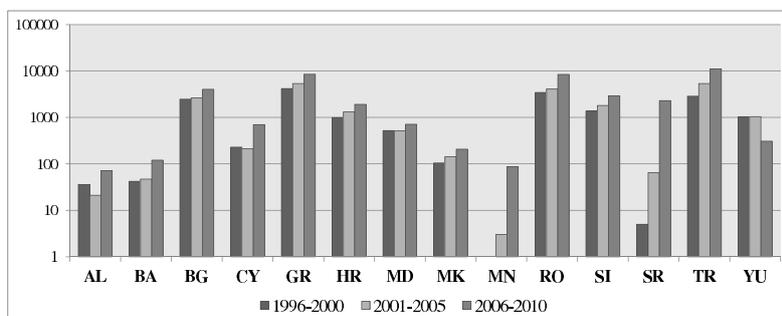


Fig. 3 – Physics publications from Balkan countries for three consecutive five-year intervals: 1996-2000, 2001-2005 and 2006-2010. Data obtained from SCOPUS database.

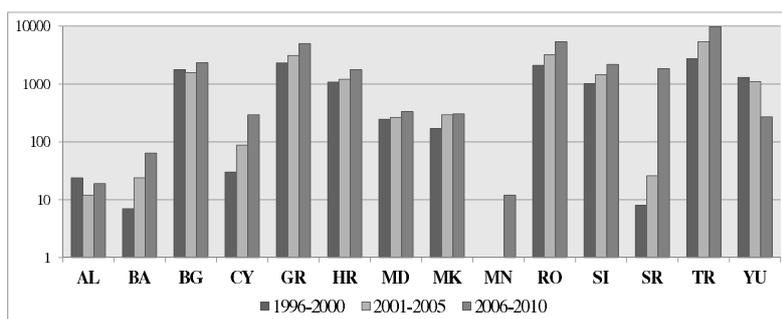


Fig. 4 – Chemistry publications from Balkan countries for three consecutive five-year intervals: 1996-2000, 2001-2005 and 2006-2010. Data obtained from SCOPUS database.

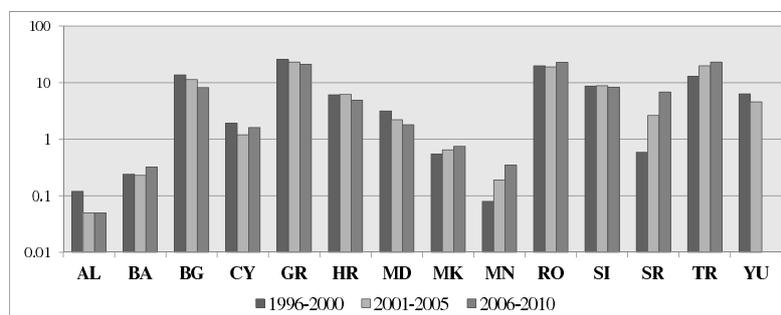


Fig. 5 – Share in the number of physics publications coming from the Balkan countries for three consecutive five-year intervals: 1996-2000, 2001-2005 and 2006-2010 (SCI data).

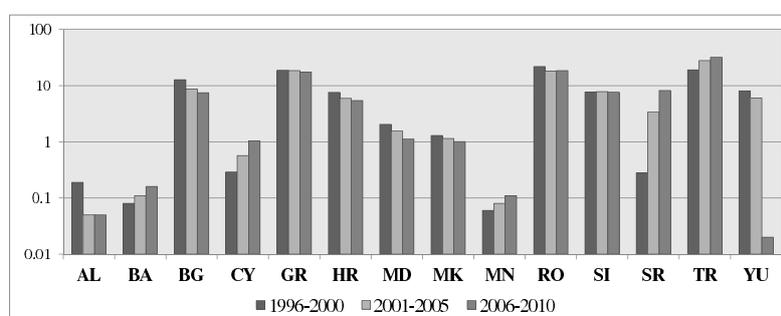


Fig. 6 – Share in the number of chemistry publications coming from the Balkan countries for three consecutive five-year intervals: 1996-2000, 2001-2005 and 2006-2010 (SCI data).

each Balkan country in the total output from the region. Only four countries have shown continuous relative growth in the number of physics publications (Fig. 5), while the others declined or show stagnation. In the years 2006-2010, according to SCI database, Turkey has increased its output to the level of 23.1% of all physics papers originating from the Balkans. Next in line is Romania with 22.7% share, followed by Greece with 21.1%. The corresponding data for chemistry publications recorded in SCI database are depicted in Fig. 6. The leading countries are Turkey (32.0%), Romania (18.5%) and Greece (17.4%). In physics, four countries have continuously increased their share in the number of publications, while in chemistry this has been achieved by five countries.

Data for relative contribution obtained from the SCOPUS database are presented in Figs. 7 and 8. For physics only Serbia and Turkey show uninterrupted relative growth, while in chemistry they are Bosnia and Herzegovina, Cyprus, Serbia and Turkey. The highest relative weight in physics publications comes from Turkey (26.7%), Greece (20.6%) and Romania (20.4%). The corresponding numbers for

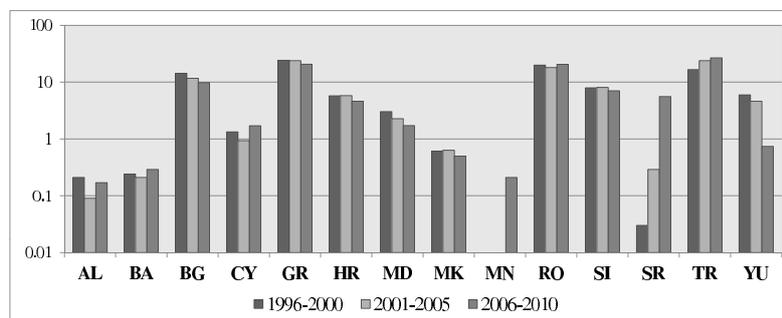


Fig. 7 – Share in the number of physics publications coming from the Balkan countries for three consecutive five-year intervals: 1996-2000, 2001-2005 and 2006-2010. Data obtained from SCOPUS.

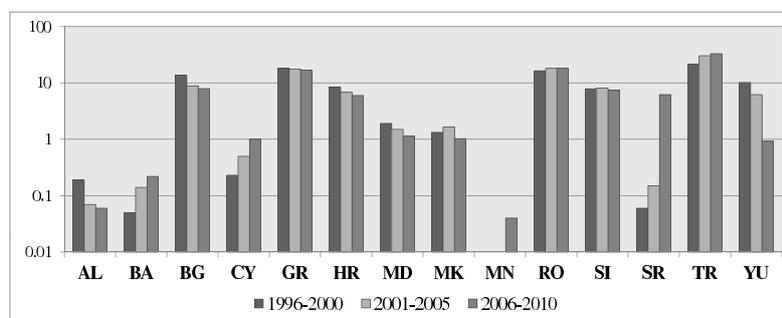


Fig. 8 – Share in the number of chemistry publications coming from the Balkan countries for three consecutive five-year intervals: 1996-2000, 2001-2005 and 2006-2010. Data obtained from SCOPUS.

chemistry publications are 33.1%, 18.1% and 16.9%, respectively for the Turkish, Romanian and Greek contribution.

The number of citations, of papers in the fields of physics and chemistry originating from the Balkans and published in the interval of five years 2006-2010, recorded in the SCI database until the middle of June 2012, are represented in Fig. 9\*. In physics, the highest number of citations has been received by papers coming from Greece (44232 citations), Turkey (33811) and Romania (23550). The highest numbers of citations of papers in chemistry are distributed as follows: Turkey (51518), Greece (41043) and Romania (18603). The next illustration (Fig. 10) provides information about the average number of citations drawn by papers in physics and chemistry with authors affiliated in the Balkan countries. The papers in the field of physics coming from Croatia (11.0) have the highest average number of citations followed by papers from Slovenia (10.4) and Montenegro (10.1). In chemistry, the

\*Data concerning Yugoslavia shown in Figs. 9-11 provide corresponding values obtained for the interval 1996- middle of June 2012.

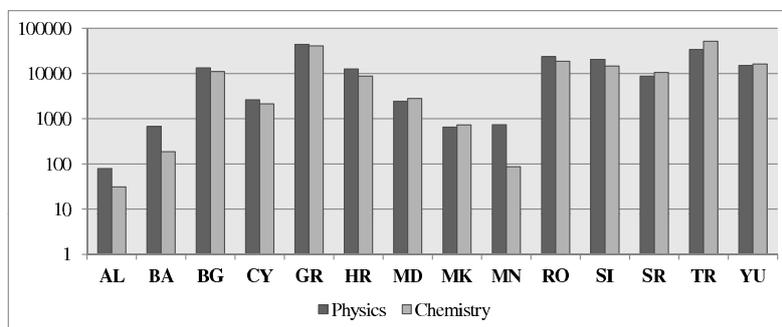


Fig. 9 – Number of citations in SCI database of physics and chemistry papers published in the years 2006-2010.

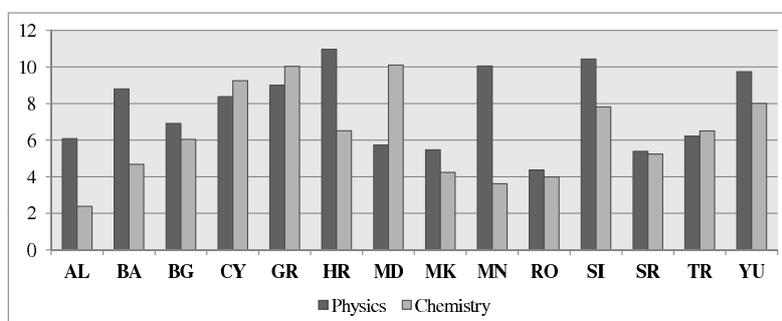


Fig. 10 – Average number of citations received by physics and chemistry papers from Balkan countries published in the years 2006-2010 (SCI data).

leading countries are Moldova (10.1), Greece (10.0) and Cyprus (9.3).

Besides the number of citations, another index introduced by Hirsch [8] has gained recognition in sciento-metric studies. The index is defined as a highest number of papers  $n$ , which have received at least  $n$  citations each. Obviously the index value is time-dependent function. In Fig. 11 an illustration is provided for the  $h$ -index for physics and chemistry for each of the Balkan countries, considering their publications in the interval of five years 2006-2010. The index was obtained from the SCI database on June 14, 2012. Countries achieving highest Hirsch index in the field of physics are Greece (67), Slovenia (52) and Turkey (50). The highest values in chemistry are acquired by Greece (58), Turkey (53) and Slovenia (38).

In the next two figures we compare the number of publications originating from the Balkans with the number of papers published in the World. In Fig. 12 the percentage of Balkan publications in the fields of physics and chemistry is shown for five-year intervals for the years 1996-2010. The data are obtained from the SCI. In Fig. 13 the corresponding data acquired from SCO are shown for each year se-

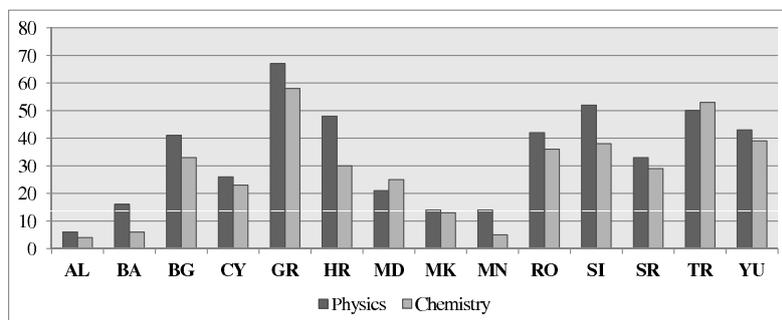


Fig. 11 – Ranking of Balkan countries by  $h$ -index, on the basis of citations of papers published in the five years 2006-2010 (SCI data).

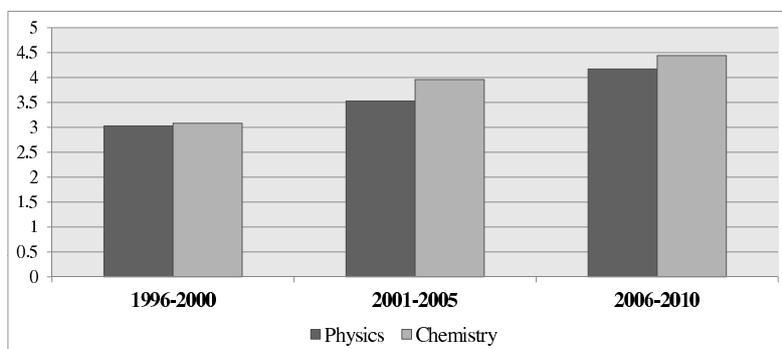


Fig. 12 – Percentage of papers from Balkan countries in World output in physics and chemistry (SCI data).

parately. Both figures clearly illustrate the same tendency of increased presence of contributions coming from the Balkan countries. According to SCI data for Balkans contribution in the number of papers in consecutive five-year intervals has grown as (3.0%; 3.5%; 4.2%) for physics and (3.0%; 4.0%; 4.4%) for chemistry. The corresponding figures from the SCO data are (2.6%; 2.8%; 3.6%) for physics and (2.8%; 3.3%; 3.8%) for chemistry.

Data about cooperation among Balkan countries for 16 years (1996-2011) were obtained only from SCI database and they are represented in Fig. 14 in four panels: a) joint papers in physics excluding CERN cooperations, b) joint papers in physics including CERN cooperations, c) joint papers in chemistry and d) joint papers in all science fields. The leading countries in overall cooperation in sciences are Greece, Slovenia and Croatia, respectively with 5592, 3420 and 3289 cooperation papers. The strongest ties are between Croatia and Slovenia, Cyprus and Greece, and Bulgaria and Greece, respectively with 1284, 986 and 882 joint papers. In physics the

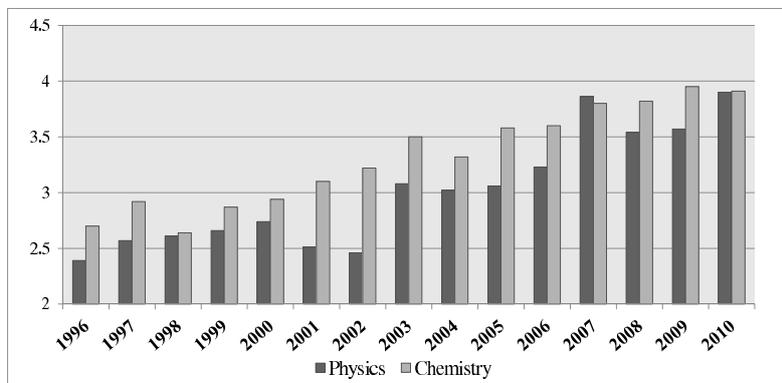


Fig. 13 – Percentage of papers from Balkan countries in World output in physics and chemistry (SCOPUS data).

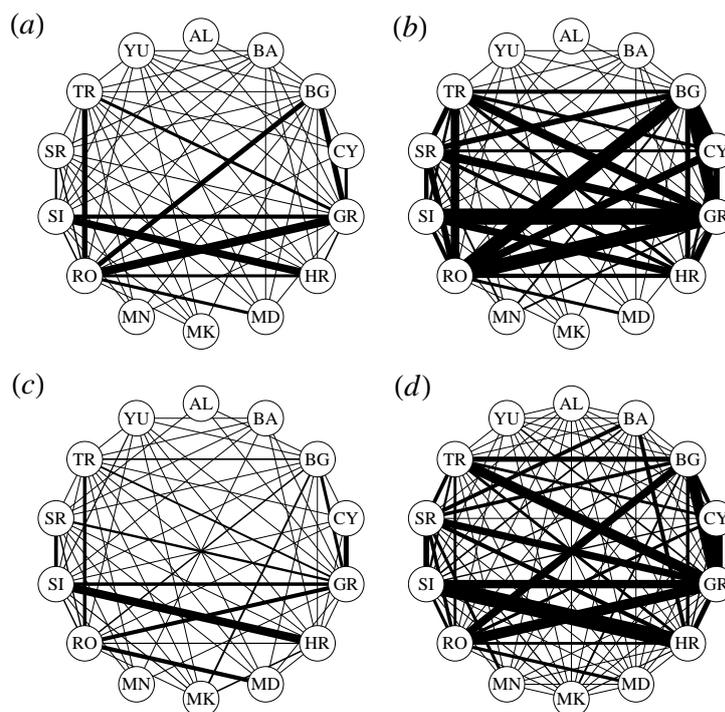


Fig. 14 – A weighted graph of scientific cooperation among Balkan countries through joint publications (SCI data). (a) Physics papers excluding CERN collaborations, (b) Physics papers including CERN collaboration, (c) Chemistry papers, (d) All papers within SCI. For visualization purposes the thickness of the edges in panel (d) is reduced to 1/3 in comparison to panels (a), (b), (c).

most significant cooperation unrelated to CERN is between Greece and Romania (232 papers), Croatia and Slovenia (205) and Bulgaria and Greece (149). The effect of CERN on cooperation in physics is huge. For example Bulgarian scientists have published in 16 years only three joint physics articles outside of CERN collaborations with scientists from Cyprus, but the number of papers through CERN cooperation is 275. Taking into account CERN cooperation, the largest number of joint papers have Greece and Slovenia (435 papers), Bulgaria and Romania (393) and Greece and Romania (388). The strongest cooperation as reflected in chemistry papers is between Croatia and Slovenia (223 papers), Cyprus and Greece (135) and Moldova and Romania (115).

#### 4. CONCLUSIONS

The data provided above show increased overall activity in the fields of physics and chemistry of the Balkan region as a whole and significantly increased presence in the international publications. The two sources used in the study show similar results. The ratio of data for the number of papers from each country obtained from the two databases in both scientific fields is nearly constant, indicating that the usage of any of the databases will give an adequate picture of the activity of each country. The picture of growth in absolute terms for each country observed in the years 2006-2010 in comparison with the previous five years in some cases changes significantly when the relative positions of the countries are observed. The reasons for the relative dwindling in the position of particular country is an interplay of many burdening factors that plague the region. According to the recent report by UNESCO [9] about the state of science in the South-East Europe, as main disadvantage for the area, for all countries except Slovenia, one considers the lack of demand for research by local economy. (This section of the report does not include Cyprus and Turkey, which are discussed in other sections.) The lack of financial support in some places is beyond imagination as the funds for science, according to the UNESCO web-site presenting data for 2008/09, stretch between 0.02% and 1.88% (Slovenia) from the GDP in various countries. The lack of jobs in general and for the young people in particular, favours brain-drain which could greatly affect the future of smaller nations. With respect to the relationship between physics and chemistry research, one may say that it is comparable for each country. Most of the countries have more publications in the field of physics, but the opposite is true for Croatia, Macedonia, Serbia and Turkey. The largest difference observed is of the order not greater than two to one.

The existing cooperation should be strengthened for the sake of research, for the benefit of the economy, and not least for the general improvement of political climate in the region. The scientists from all branches, but physicists and chemists

in particular have the capabilities to assist in this effort. One may hope that further increase in the activity will bring also more significant results.

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