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How Open Access became reality in High Energy Physics

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1. An Introduction to Open Access

Open Access is the vision of free and unrestricted access to scientific information for everyone. It has long been a dream of scholars all over the world to have the ability to read and reuse academic publications without paywalls or any other barriers. Making it easy to share knowledge amongst scholars is supposed to accelerate scientific research and create economic prosperity for the benefit of everyone. Additionally, the wider (interested) public can read research articles and might discover something even no professional researcher had thought of. In 2001, the Budapest Open Access Initiative[1] created a movement of numerous activists, who have since been striving to promote the idea of free, easy and unlimited access to the results of publicly funded research.

The digitalization of our world makes it technically easy to copy and distribute scientific articles. There is no longer the need to print and ship physical copies of academic journals. Information can be made accessible globally with only a mouse click and each scientist in the world could read the same article simultaneously. The idea of free and easy access to scientific information has gained tremendous momentum[2]. Fifteen years after Budapest, Open Access (OA) is on the agenda of many politicians and policy makers. Several private funders of research, such as the Bill

1) http://www.budapestopenaccessinitiative.org

2) http://oaspa.org/oaspa-members-ccby-growth-2015-data/

Gates foundation or the Wellcome Trust, make it mandatory to publish the results of supported projects Open Access. In May 2016, the European Competitive Council has claimed that Open Access should be the default at latest by 2020[3].

Currently, one can distinguish two main ways to achieve Open Access: they are usually referred to as Green OA and Gold OA. [1] **Green Open Access** calls for the deposit of a version of the article to a repository. This typically happens before the manuscript goes through the editorial and peer-review process of a journal and the version deposited is called a "pre-print". Green OA for a final version of the article is often subject to an embargo period at the discretion of the publisher. The alternative is **Gold Open Access** where the final, peer-reviewed article becomes immediately available on the publisher's websites. In many cases the publisher requires the author (directly or via its institution or funder) to pay for an article to be Gold OA. As a response to the increasing demand, many publishers have started Gold OA journals or offer an OA option for their subscription journals (hybrid journals). [2]

In High Energy Physics (HEP), Open Access has a much longer tradition than in other disciplines. Particle physicists were already starting to exchange their (paper-based) pre-print versions of scientific articles back in the 1960's. In 1989, while working at CERN - the European Organization for Nuclear Research, Sir Tim Berners-Lee invented the **World Wide Web**[4] to support the dissemination of scientific data and results. To simplify the exchange of pre-prints, the HEP community quickly adopted this new technology by using the arXiv.org platform, a repository hosted by the Cornell University[5]. arXiv.org was established in 1991. Within eight years, more than 90% of all HEP pre-prints were available online. [3] Based on this tradition, CERN initiated the **Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP3)**[6], one of the largest Open Access initiatives to date. SCOAP3 is a collaboration between 3,000 libraries, research institutions and funding agencies in 47 countries and intergovernmental organizations. It has established immediate Gold Open Access for a large part of the scientific output in High-Energy Physics. This article will reflect on the development, achievements and forward vision of SCOAP3 ten years after the first emergence of the model.

2. Collaboration, Publications and the History of SCOAP3

There is probably no other scientific discipline that has such a long tradition of international collaboration as High-Energy

3) http://www.consilium.europa.eu/en/meetings/compet/2016/05/26-27/

4) https://home.cern/topics/birth-web

5) http://arxiv.org/help/general

6) http://scoap3.org

Physics. For decades, teams of experimental physicists have collaborated to build and enhance complex accelerator and detector experiments. The realization of huge machines, such as the Large Hadron Collider (LHC) at CERN, was only possible by combining the resources and expertise of hundreds of universities and research institutions from all over the world. Such collaborations could consist of only a few physicists but could also include several thousand members.

Accelerators are built to generate new particles through collisions of other particles at very high energy levels. The detectors placed at the collision points of the accelerators collect an enormous amount of data. Numerous international teams of physicists use data collected in the experiments to validate existing theories or to predict new discoveries beyond the known models of particle physics. Overall more than **20,000 physicists** [4] are working on the experiments across the globe or in theory departments of universities and research institutions. Most of them publish the results of their activities regularly in scientific articles.

Central hubs, such as CERN in Europe or Fermilab in the United States, provide supporting infrastructure for the research community which often goes beyond the actual accelerator and detector technology. The global Open Access publishing initiative SCOAP3 is an example of such an infrastructure initiated and operated by CERN following its mission to support the dissemination of scientific information. [5]

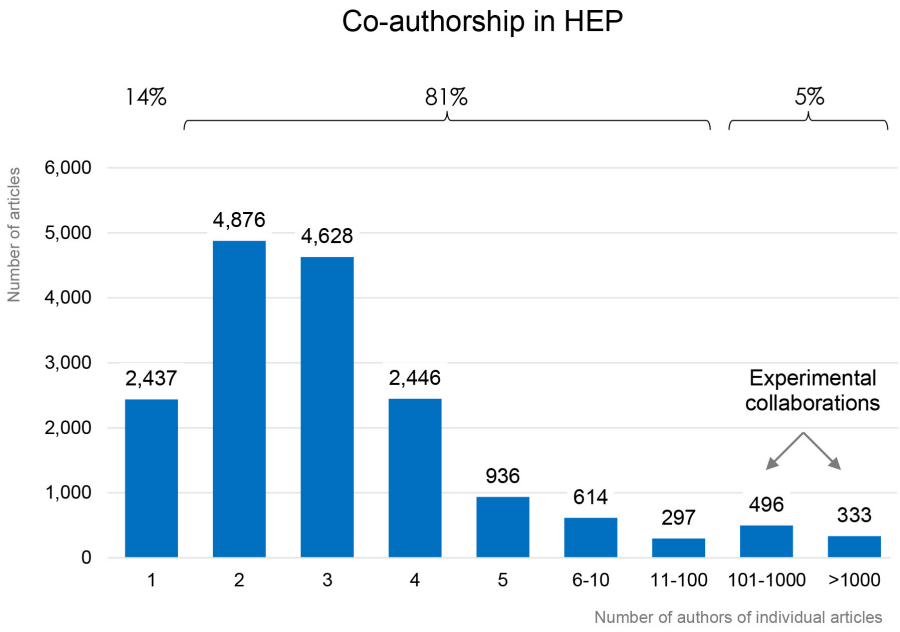
The HEP community annually produces **~7,500 scientific articles**[7] published in 153 journals. While there is apparently a large variety of journals carrying HEP relevant publications, 90% of the publications can be found in only 15 journals. On average, all the remaining journals contain less than 10 HEP articles per year. The fact that most HEP articles are being published in a rather small set of journals has significantly supported the emergence of a centralized Open Access model.

Contrary to the high level of public attention HEP experiments such as ATLAS or CMS at CERN's LHC receive, experimental papers only account for a small fraction of the academic HEP output[8]. The vast majority of the annually produced articles are authored by individual theorists or small teams within theory departments. Figure 1 shows the number of articles produced in 2014-2015 in the key HEP journals[9]. The distribution of number of authors shows two important aspects for publishing in HEP: (1) the number of articles

7) Based on a retrieve from InspireHEP as of July 25th 2016, considering all HEP articles 2014-2015 deposited to arXiv as HEP (hep-ex, hep-lat, hep-ph, hep-th)

8) 6% of all HEP articles 2014-2015 listed in InspireHEP were classified hep-ex (experimental HEP) in arXiv

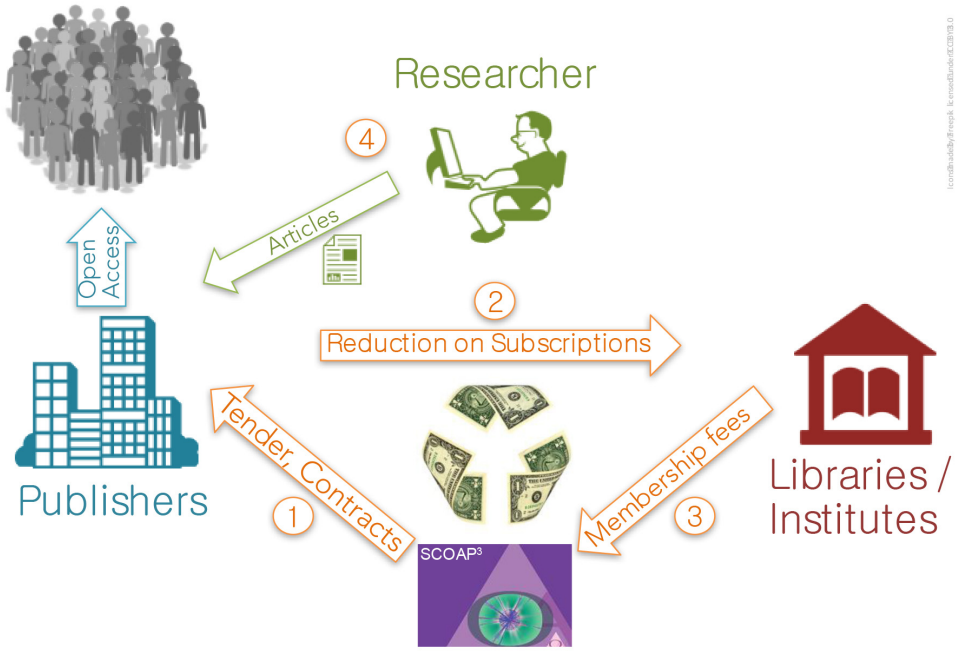
9) 10 SCOAP3 journals (http://scoap3.org/scoap3journals) plus the 6 non-SCOAP3 journals with most HEP articles: PRC, PRD, PRL (APS); Int.J.Mod.Phys., Mod.Phys.Lett. (World Scientific); Class.Quant.Grav. (IOP Publishing). Journals with clear HEP focus are considered with all their articles irrespective of the scientific discipline



(Figure 1) Distribution of number of authors for 2014–2015 articles in 16 journals representing 90% of all HEP

from big experimental collaborations is rather small but they carry very high complexity due to the enormous number of co-authors (up to 3,000). (2) only 14% of all HEP articles are authored by one individual researcher so the publishing processes have to cater for co-authorship.

At the beginning of this century, nearly all HEP pre-prints were available as Green OA via arXiv.org [3]. Even so, researchers continued publishing their articles in journals that were mostly subscription based. This means that the official peer-reviewed version of record of an article remained locked behind paywalls. Initiated by the CERN Director General Dr. Robert Aymar, a working group of physicists, librarians and OA specialists was formed in 2006 to develop a solution for immediate Open Access to the final peer-reviewed scientific article. The recommendations of the working group were presented in 2007 [6] and suggested the creation of a global consortium operating under an innovative business model: the funds, libraries are spending to subscribe to HEP journals, should instead be used to pay for the full or partial transition of existing journals to Open Access. This transition should not only allow immediate open and unrestricted access to the research articles at no burden to authors but should also contain the overall cost of journal publishing in HEP. Today, such a transition of journals is commonly called “flipping”.



(Figure 2) SCOAP3 Business Model – schematic view

The SCOAP3 business model can be explained as follows (see Figure 2):

(1) CERN (for the benefit of SCOAP3) awards contracts to publishers as a result of a competitive tendering process. The contracts define a set of services to be provided, a price to be paid for the publication of an article, a maximum contract amount as well as technical details such as the type of Open Access license (typically CC-BY).

(2) Publishers reduce or eliminate subscription costs to the participating journals for all their customers.

(3) The reduction of subscription costs, frees funds at libraries who then can redirected them to a central fund from which the publication costs are paid (1).

(4) HEP researchers retain copyright to their work and benefit from Open Access at no cost or administrative effort. They can continue to focus on research and publish results in their preferred journals.

In today's political environment new national or institutional "offsetting" agreements emerge almost on a monthly basis[10]. A prominent example are the agreements of Dutch universities with several large publishers. [7] Back in 2006 though, when the SCOAP3 working group introduced the concept of a

10) "offsetting" agreements contain a subscription and a APC component in one contract allowing authors to publish Open Access in the subscribed journals.

centrally organized transition of existing subscription journals to Open Access, this was something radically new. The research community, university libraries, national funding agencies and scientific publishers needed to work closely together to transform the idea into a viable operation. Such collaboration amongst different stakeholder groups required a long and complex consensus building process. The legal and commercial concepts had worked well for building a 27km long underground particle accelerator. But they were not known in the scientific publishing industry yet. SCOAP3 was a prototype of itself and hence the preparation process lasted several years. Finally, after 8 years of preparatory activities, the operation of SCOAP3 started in January 2014, supporting HEP publications in 10 journals[11].

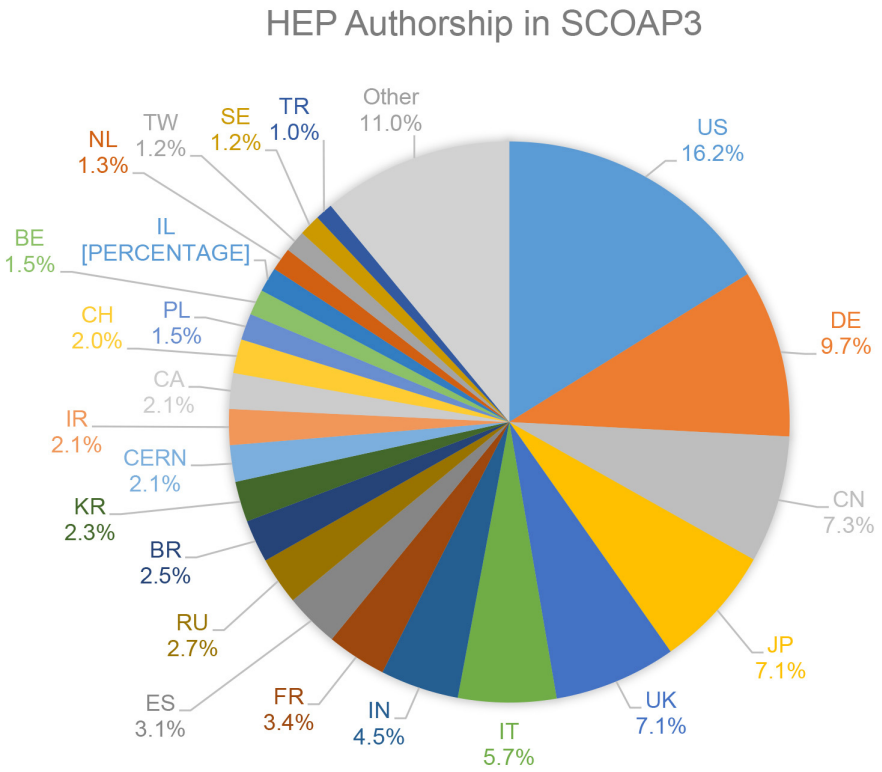
3. 3,000 Partners Working Together

Initially, the consortium consisted of about 1,000 libraries from 15 countries. For the first time a global collaboration was created amongst libraries, research institutions and funding agencies partnering with three commercial and eight society publishers. During the following months of successful operation, SCOAP3 grew to a community of more than **3,000 partners from 47 countries** and intergovernmental organizations[12]. University libraries, research institutions and funding agencies from five continents joined forces to ensure sustainability of the largest global Open Access initiative to date. The number of partners continues to grow steadily, with more countries and institutions expected to join the initiative.

SCOAP3 has established a fair and equally engaging governance structure[13]. All partners are encouraged to actively participate in the decision making process and to contribute ideas for the development of the initiative. The **SCOAP3 Governing Council** is the decision-making body of the partnership responsible for its overall governance and strategic direction. The Governing Council is composed of representatives from all countries. It appoints the Executive Committee and the Working Groups and meets at least once a year.

The day-to-day management is overseen by the **SCOAP3 Executive Committee**. This governance body meets at least once a month to receive reports from and provide guidance to the operations team at CERN and to take decisions within the competencies delegated to it. The Executive Committee ensures a smooth operation and manages relations with partners and participating publishers. Its 4-6 members are appointed for 2 years by the Governing Council striving for geographical balance across all regions.[14]

11) https://scoap3.org/scoap3journals
12) https://scoap3.org/participating-countries/
13) https://scoap3.org/what-is-scoap3/
14) SCOAP3 Memorandum of Understanding, Clause 3



(Figure 3) Share of authorship of 2014–2015 articles in the SCOAP3 journals by country

The Executive Committee is supported by several **Working Groups** and committees. They provide advice on dedicated topics such as outreach to new partners or the wider public or the technical development of the IT platform necessary to operate the consortium.

By joining the SCOAP3, all partners agree to contribute financially to the central fund out of which the partnership pays the OA publication of articles in the participating journals. The contribution is set at a country level and is supposed to be a "**fair share**". The working group that proposed the SCOAP3 model in 2007 suggested to use the country's share in HEP publications as a basis to determine the contributions. As previously discussed, co-authorship is a very prominent phenomenon in the field. A dedicated algorithm has been adopted by the Governing Council to address the common international collaboration. The results of the most recent calculation of the geographical distribution authorship are shown in Figure 3[15].

Libraries typically contribute by redirecting the money previously used for subscribing to the SCOAP3 journals. In some countries the

15) Based on 8,752 articles published in 2014-2015 in the SCOAP3 journals

total amount available from these redirected subscription funds is larger than the "fair share" the country is supposed to contribute. In these cases, libraries in the country can either benefit from a net saving or voluntarily contribute more.

However, in some countries the opposite is the case: redirected subscription money is not sufficient to cover the "fair share". This typically happens in countries with a quickly growing HEP community (e.g. China) or countries that are historically very strong in particle physics (e.g. the United Kingdom). As the collective funds of libraries are not enough to cover the share of the country, other sources are required. In such cases a funding agency or a central government body might step in and ingest "**fresh money"** in order to meet the country's obligation. As funding agencies will need to fill only the gaps in such cases, it is usually much more attractive for them to support SCOAP3 than other OA models where they need to pay the entire OA publication fee (APC[16]).

Globally, more than three quarters of the SCOAP3 budget is financed with redirected subscription funds from the participating 3,000 libraries. The remaining quarter is supported by funding agencies filling national gaps or directly by CERN (covering what is missing).

16) APC = Article Processing Charge – fee authors have to pay to the publisher to make an article Open Acces

4. Low Price and High Quality

Since its start in 2014, SCOAP3 supported the publication of more than **11,700 OA articles** at no cost for the authors. This represents approximately 50% of all scholarly articles published in HEP during this period. Table 1 below lists all participating journals and the number of published articles since the launch of SCOAP3[17].

There are two different ways how a journal can participate: journals that predominantly publish High-Energy Physics articles are entirely supported by the consortium and hence are transitioned to full OA journals. They are highlighted in Table 1 in bold. Some participating journals have a broader scope that goes beyond HEP. In such cases SCOAP3 will only support the HEP related[18] part of the journal while the remaining content might still be under a subscription model (hybrid journals) or might be Open Access by other means.

Irrespective of the model applied, SCOAP3 aims to avoid any disruption to the research process. Articles are submitted by the authors to their preferred journal where they follow the standard editorial process. Publishers deal

17) Data taken from the SCOAP3 Repository (https://repo.scoap3.org) as of July 28th 2016

18) HEP related articles are determined using the arXiv classification very common in High-Energy Physics since more than 25 years. An article is considered HEP if the author(s) have submitted the article to arXiv in one of the categories hep-ex, hep-lat, hep-ph, hep-th.

〈Table 1〉 List of SCOAP3 journals and number of articles supported

Journal	Publisher	# articles
Acta Physica Polonica	Jagiellonian University Krakow	50
Advances in High Energy Physics	Hindawi Publishing	457
Chinese Physics C	IOP Publishing / Chinese Academy of Sciences (CAS)	74
European Physical Journal C	Springer / Societa Italiana di Fisica (SIF)	1,554
Journal of Cosmology and Astroparticle Physics	IOP Publishing / SISSA	564
Journal of High Energy Physics	Springer / SISSA	5,497
New Journal of Physics	IOP Publishing / German Physical Society (DPG)	23
Nuclear Physics B	Elsevier	920
Physics Letters B	Elsevier	2,401
Progress of Theoretical and Experimental Physics	Oxford University Press / Physical Society of Japan (JPS)	195
Total		**11,735**

directly with SCOAP3 as far as publication fees are concerned. Authors retain the copyright of their work and automatically benefit from the fact that their articles are made available Open Access in a way compliant with their funders or universities mandate.

Controlling costs has always been an important objective of SCOAP3. Publishers want to be appropriately compensated for the services they provide. At the same time the consortium members expect a high level of transparency and cost control. The centralized design of the SCOAP3 model supports this asymmetry much better than models where authors make direct payments of APCs to publishers. Individual scientists have neither the resources nor the expertise to apply efficient means of cost control. The CERN procurement tools had already been tested in large scale projects such as the construction of a multi-billion Euro particle accelerator. The same principles and processes were applied for a competitive tendering process to award SCOAP3 contracts. For each journal a discounted price per article (APC) was agreed together with a maximum annual number of articles to be paid for (cap). Articles published beyond this cap are made available Open Access at no additional cost for the consortium. The combination of both factors lead to an average **costs per article of 1,100 Euro** [8]. This is well below the official list prices for comparable Gold or Hybrid journals and also more advantageous than for instance the average APCs paid by individual institutions, such as the German universities (€ 1,288[19]) or the UK Higher Education Institutions (€ 2,188[20]). A recent study did further analyze these data from Germany and the UK together with additional information from Austria, Canada and the United States [2]. The average APCs

19) Source: https://github.com/OpenAPC/openapc-de

20) Source: http://figshare.com/articles/2015_Jan_June_UK_APC_data_combined/1509860

paid vary between € 1,610 (full OA journals) and € 2,620 (hybrid journals) with no major differences across scientific disciplines. But also private research funders pay high prices to make the results of their research available in Open Access. The average APC paid by the Wellcome Trust, a U.K. based charity that provides research grants mainly in the field of biomedical science, is even higher at € 2,37 7[21]. From all the publically available information about APC payments, it seems fair to say that the average cost per article of SCOAP3 is the best value-for-money on the market for scientific Open Access publishing.

Paying an APC should make the article freely accessible on the publisher's website (Gold OA). But it needs more to make an article compliant with current Open Access mandates and policies. For each journal, SCOAP3 has defined high **quality standards**, which have to be met in order for an article to be considered compliant and hence fully paid for by the consortium:

- The article has to be freely accessible on the publisher's website and has to be delivered to the SCOAP3 Repository[22] for further distribution.
- The license under which the article is made available should allow for a wide re-use such as text or data mining. SCOAP3 uses the Creative Commons CC-BY license[23] which is considered most permissive.
- All metadata of the article should be freely available following certain standards.
- The article should be available in specific file formats (e.g. PDF or XML).
- All the above should happen immediately after publication.

The statistics of the first 2.5 years show that **99.98%** of the SCOAP3 articles are compliant with the defined standards. To date, only two articles were delivered late and hence not compliant with the requirements.

How does this compliance rate compare with other OA initiatives? The aforementioned Wellcome Trust adopted a strict Gold OA policy already many years ago and since then supports APC payments with its grants. Wellcome is regularly analyzing its OA activities including achieved article compliance. According to the most recent report, almost one third of the OA articles were not fully compliant with Wellcome's requirements. Even though an APC was paid, Wellcome did not get the expected results – but why? As most other OA funders, the Wellcome Trust operates a decentralized model. The authors receive a research grant which is also used to pay an APC directly to the publisher to make the article OA. But authors typically have neither the time nor the tools to systematically perform a quality assurance process. At the same time the production processes of publishers are often

21) Source: https://blog.wellcome.ac.uk/2016/03/23/wellcome-trust-and-coaf-open-access-spend-2014-15/

22) https://repo.scoap3.org

23) https://creativecommons.org/licenses/by/4.0/

not equipped to handle Open Access articles in accordance with the hundreds of different policies that exist today[24]. Most of the publisher systems were developed to cater the needs of a subscription journal.

Aiming for article compliance in such a decentralized set-up comes with significant cost. A 2014 study analyzed the total spent of UK research organizations for Open Access. [9] The UK institutions spent almost the same amount to ensure compliance with the RCUK OA policy[25] as for the actual APCs.

On the contrary the SCOAP3 operations team at CERN has established centralized quality control tools. Several automated and manual validation processes aim to ensure that each article meets the defined compliance criteria. This central implementation does not only lead to close to 100% article compliance, the measures can also be implemented in a very cost efficient way.

5. The Path Ahead

In June 2015, the SCOAP3 Governing Council initiated the preparation of a 2nd three-year cycle covering **2017 to 2019**. All SCOAP3 partners confirmed their continued support of the consortium during this second phase and also CERN reassured its role of hosting and operating the initiative. The Executive Committee conducted a sound analysis of the first years and obtained extensive feedback from the consortium members. Supported by the SCOAP3 governance, CERN concluded constructive negotiations with the publishers in spring 2016 and the contract extensions were signed by CERN and the scholarly publishers in July. Negotiations did not conclude for two journals published by IOP Publishing together with two learned societies. It seems that publications in both journals will not be supported after 2016. Nevertheless, the consortium remains open for a potential future enlargement of the HEP journal coverage.

SCOAP3 was a real innovation at the time the concept was presented almost 10 years ago. Since then it is perceived as a role model for transitioning the subscription based system into Open Access. Recent national or institutional “flipping” agreements (e.g. the agreements of the Dutch consortium with Springer and Elsevier) follow a similar approach by primarily reusing existing funds formerly spent on subscriptions. Experts of several scientific disciplines have approached the SCOAP3 governance to learn from the experience gained and to investigate how the model can be ported to other fields. The ambitious transitioning project OA2020, initiated by the German Max Planck society, is aiming for a total transition of scientific publishing to Open Access [10]. They explicitly refer to SCOAP3 as an inspiration but also as practical example for an international implementation. All these examples hint that SCOAP3 paved the way for

24) http://roarmap.eprints.org
25) Research Councils UK OA policy: http://www.rcuk.ac.uk/research/openaccess/policy/

an accelerated transition process towards OA publishing across disciplines. By now entering into its second 3-year cycle SCOAP3 has proven that a large-scale transition is a sustainable model for the future of scientific publishing and the vision of Open Access has become reality.

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He holds a PhD in Physics and is head of Open Access at CERN, where he co-architected the SCOAP3 initiative. Together with partners in the U.S., Germany and China, Salvatore's team runs the INSPIRE service (inspirehep.net), a global OA digital library for HEP. His team has been developing solutions for Open Data at the service of CERN scientific community (opendata.cern.ch) and beyond. Salvatore serves on the Boards of Director of the ORCID and the DataCite initiatives.

Before focusing on Open Access, Salvatore enjoyed a carrier in physics as a research scientist both at CERN and at the Italian National Institute for Nuclear Physics, measuring fundamental physics constants and searching for such exotic things as extra space dimensions.

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He works at CERN as SCOAP3 Operations Manager. In this role he supports the Executive Committee to ensure financial and operational effectiveness of SCOAP3. Alex acts as an intermediary between the 3,000 partner institutions on the one side and the commercial and society publishers on the other side and coordinates the involved teams at CERN. Alex joined the project with 20 years of experience from the financial industry where he worked in various roles primarily in operations, project and business management.