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Synchrotron Light and the Middle East: Bringing the Region's Scientific Communities Together through SESAME

Chris Llewellyn Smith

RECENT headlines about the Iranian nuclear program, the Israeli-Palestinian conflict, and the uncertain implications of the Arab Spring in countries such as Egypt, have focused attention on a turbulent region where tribal, religious, and cultural tensions impact domestic politics and international relations. Lost in these stories are efforts to promote international cooperation and collaboration for a common good. SESAME (Synchrotron-light for Experimental Science and Applications in the Middle East)—a major intergovernmental scientific facility under construction near Amman, Jordan, whose members are Bahrain, Cyprus, Egypt, Iran, Israel, Jordan, Pakistan, the Palestinian Authority, and Turkey—is an example of such an activity.

SESAME, which has a target date for commissioning in late 2015, is modeled on CERN, the European Organization for Nuclear Research, although the scientific aims are very different. CERN was conceived in the aftermath of World War II with the explicit twin aims of enabling science that the members individually could not afford and contributing to strengthening links between countries that had recently been at war. Similarly, SESAME is beyond the reach of most of the members' individual science budgets (and will require a range of skills that few of them currently fully possess) and has two aims:

Chris Llewellyn Smith is the president of the SESAME Council and was the director-general of CERN from 1994 to 1998.

- Foster scientific and technological capacities and excellence in the Middle East and the Mediterranean region (and prevent or reverse the brain drain) by constructing an outstanding scientific device and enabling world-class research by scientists in a diverse range of fields including biology and medical sciences, materials science, physics and chemistry, and archaeology.
- Build scientific links and foster better understanding and a culture of peace through scientific collaboration. As the language of science is universal, scientists can try to build a bridge of understanding and perhaps trust for the benefit of all.

The success of CERN inspired and assisted the creation of many other scientific organizations in Europe (such as the European Molecular Biology Laboratory, the European Southern Observatory, and the European Synchrotron Radiation Facility). If successful, SESAME may not only emulate CERN's scientific and political success, but will also inspire and cultivate other collaborations. While the project continues to face challenges, a lot of progress has been made thanks to the efforts of the members, especially Jordan, the enthusiasm of the scientists involved, and widespread international support.

Synchrotron-Light Sources

In synchrotron-light sources, bunches of electrons circulate at nearly the speed of light inside an evacuated tube, which is bent into a ring (in SESAME, the average internal diameter of the tube is some 5 centimeters and the length of the ring is 133 meters). As magnets surrounding the tube bend the electrons' trajectories, the electromagnetic field that surrounds them is unable to respond instantaneously and some of the energy in the field keeps going, producing a tangential cone of radiation. This radiation, or 'synchrotron light,' has wavelengths that range from the infrared to x-rays and can be used to study matter on scales ranging from viruses down to atoms. SESAME will be a competitive third-generation light source, meaning that it will be equipped with devices ('wigglers' and 'undulators') in straight sections of the ring that will create magnetic 'bumps' in the electrons' road. Forward-going radiation, produced as successive bumps shake off part of the electromagnetic field, adds up and produces beams that are much more intense than those produced by bending in the curved sections. Obviously, these light sources are capital intensive and very expensive projects requiring sophisticated technical capacities.

The synchrotron light is collected by different 'beamlines' (optical systems) connected to the ring that focus the light on to experimental 'targets,' allowing many experiments to be run simultaneously. As with other synchrotron-light sources, the scientific 'users' conducting experiments at SESAME will be based in universities and research institutes in the region. They will visit the laboratory periodically to carry out experiments, generally in collaboration, where they will be exposed to the highest scientific standards, and then later analyze their data at home.

The Origins of SESAME

Synchrotron-light sources have become an essential tool in a very wide range of applied and basic sciences. There are more than sixty such light sources in the world, including a few in developing countries, but none in the Middle East. Eminent scientists, including the Pakistani Nobel laureate Abdus Salam, understood the need for an international synchrotron-light source in the Middle East as long as thirty years ago. It was also understood by the CERN-based MESC (Middle East Scientific Cooperation), headed by Sergio Fubini. Their efforts to promote regional cooperation in science, and also solidarity and peace, started in 1995 with the organization of a meeting in Egypt at which Venice Gouda, the Egyptian Minister of Higher Education, and Eliezer Rabinovici, of MESC and Hebrew University in Israel, took an official stand in support of Arab-Israeli cooperation.

In 1997, Herman Winick of the SLAC National Accelerator Laboratory at Stanford University in the United States and Gustav-Adolf Voss of the Deutsches Elektronen Synchrotron in Germany suggested building a light source in the Middle East using components of the soon to be decommissioned Berlin Synchrotron, BESSY I. The MESC pursued this brilliant proposal, and, in 1999, persuaded Federico Mayor, then director-general of the United Nations Educational, Scientific and Cultural Organization (UNESCO), to convene a meeting of delegates to UNESCO from the Middle East and neighboring regions. Together, they launched SESAME and set up an International Interim Council under the presidency of Herwig Schopper (who is a former director general of CERN).

After a competition with five other countries, the council selected Jordan to host the center. The German government donated the components of BESSY 1 to SESAME. UNESCO funded the dismantling costs with additional contributions from members, the U.S. Department of State, and the Abdus Salam International Centre for Theoretical Physics (ICTP) in Trieste, Italy.

In May 2002, the UNESCO Executive Board unanimously approved the establishment of SESAME under the auspices but completely independent of UNESCO, which is the depository of SESAME's statutes (as it is for CERN, which was also established under the auspices of UNESCO). The center formally came into existence in April 2004.

Members' decisions to join SESAME, which were made at a time when tensions in the region were lower than they are today, did not attract much attention. Different members followed different procedures. For example, in Israel, which was involved from the start (although Israelis already have access to the European Synchrotron Radiation Facility as a contributing Scientific Associate) and whose presence is a major element of the political rationale for SESAME, many bodies were involved, including scientists, the Academy of Sciences and Humanities, the Ministry of Science, and the Planning and Budgeting Committee of the Council for Higher Education. In Iran (which, although it had been involved from a very early stage, did not formally join until 2007), where the science base is one of the fastest growing in the world and there is an especially strong scientific case for joining SESAME, there was a vote (152 for joining, 6 against) in the Parliament.

International Support for SESAME

From the beginning there has been wide international interest in and support for SESAME. France, Germany, Greece, Italy, Japan, Kuwait, Portugal, the Russian Federation, Sweden, Switzerland, the United Kingdom, and the United States are observer countries. Their representatives at SESAME Council meetings are generally experienced synchrotron-light users who provide invaluable advice. The four SESAME Advisory Committees (Beamlines, Scientific, Technical, and Training) contain senior scientists and accelerator experts from Canada, France, Italy, Japan, Kuwait, Spain, Switzerland, the United Kingdom, and the United States, as well as ICTP and, of course, the SESAME Members.

Following the example set by Germany, equipment that had become surplus to requirements has been donated by France, Italy, Switzerland, the United Kingdom, and the United States. For example, the United Kingdom donated components of five beamlines from its Daresbury synchrotron. European, American, and Japanese centers are also contributing valuable assistance and advice in designing, constructing, and utilizing SESAME.

The important training program has been almost entirely funded by the generosity of outside bodies who are inspired by the vision that underlies the project—including international organizations (the International Atomic Energy Agency [IAEA], UNESCO, ICTP, the European Synchrotron Radiation Facility, and the European Union LinkSCEEM project), and national organizations and synchrotron laboratories (in Brazil, France, Germany, Italy, Japan, Portugal, Spain, Sweden, Switzerland, Taiwan, the United Kingdom, and the United States). The program is also funded by scientific bodies (the American Physical Society, the American Chemical Society, Deutsche Physikaliche Gesellschaft, the European Physical Society, the Institute of Physics, and the International Union of Pure and Applied Physics) and by two foundations (the Canon Foundation for Scientific Research and the Richard Lounsbery Foundation).

The SESAME Training Program

SESAME is already contributing to building scientific and technological human capacity in the Middle East and neighboring regions. A series of users' meetings and excellent training opportunities (supported by IAEA, various governments, and many of the world's synchrotron laboratories) are helping to foster the potential user community—which numbers more than two hundred—and are already bringing significant benefits to the region.[1]

Eight synchrotron-radiation laboratories in Europe kick-started the SESAME training program by providing long-term fellowships to train sixteen scientists and engineers from the region as accelerator specialists—a number of whom are now building SESAME. In parallel, eleven scientists from the region received training in the United States on applications of synchrotron radiation, thanks to support from the U.S. Department of Energy. This was strongly reinforced by subsequent substantial funding from the IAEA. Initially, the focus was mainly on training accelerator physicists, but it has now switched to training beamline scientists and future SESAME users from the region.

During the last decade, more than four hundred scientists and engineers participated in twenty-one SESAME users' meetings, workshops, and schools in the Middle East and elsewhere on the use of synchrotron light in biology, materials science, and other fields, as well as on accelerator technology. Approximately seventy-five of these men and women have spent periods of up to two years working at synchrotron-radiation facilities in Europe, the United States, Asia, and Latin America (mostly in countries that are SESAME observers). This has given scientists from the SESAME Members the opportunity to use existing light sources while SESAME is under construction, thereby providing them with first-hand experience and further swelling the ranks of Middle Eastern scientists with experience in using synchrotron-radiation sources. Besides increasing the technical capacities of the scientists and engineers in the region, the training program has also helped to foster individual relationships between scientists in the region and with scientists in the observer countries.

The Status of SESAME

The original proposal was to upgrade and rebuild the second generation BESSY 1. The SESAME Members joined on the understanding that, although they would be required to cover the manpower and operational costs, they would not be required to contribute to capital costs, Jordan having agreed to provide the building and land. In 2002, however, this plan was abandoned in favor of building a third-generation light source with a completely new—much larger—main ring (fed with electrons from the upgraded BESSY 1 'booster' synchrotron, which in turn will be fed by the upgraded BESSY 1 'microtron'). This new main ring will store electrons with an energy of 2.5 GeV (gigaelectronvolts). The decision to build a competitive higher energy third-generation device, which will attract the best scientists from across the SESAME region, helps ensure the future success of SESAME. However, when the decision was made, it was mistakenly thought that an outside source would cover the additional cost. Finding the necessary capital funding has been a huge challenge, which has only been partially solved in recent months.

Nevertheless huge progress has been made. At the time of writing, the value of investments made plus in-kind contributions that will be in use on day one of operation total some $50 million. The SESAME building was opened in November 2008 in a ceremony under the auspices of His Majesty King Abdullah II of Jordan, and with the participation of His Royal Highness Prince Ghazi Bin Muhammad of Jordan and Koïchiro Matsuura, then director-general of UNESCO. The radiation shielding has all been built, the cooling and ventilation system is being manufactured and installed, the refurbished microtron is in place and has produced a beam at full energy, and commissioning of the refurbished and upgraded booster synchrotron, which is currently being installed, should begin in mid-2013.

An additional $36 million of capital investment is needed to provide the main 2.5 GeV ring and supporting infrastructure, and bring SESAME into operation with four day-one beamlines (three based on cannibalized components of donated beamlines, refurbished and adapted to work at SESAME, and one completely new). It will also fund a security system and a guest house, which will allow users to work intensively during visits to SESAME and is necessary for visitors from some of the SESAME Members given the political tensions in the region. Subsequently, a further $24 million will be needed to provide additional radio frequency power to bring SESAME to its full performance, for three more beamlines, and to provide additional office space and a meeting/conference center. When SESAME is not in operation, the guest house and conference center could be used to hold international meetings on issues from agriculture or water resources to archaeology, in secure surroundings in one of the few countries in the region to which access is relatively easy for all.

In March 2012, Iran, Israel, Jordan, and Turkey each agreed to make voluntary contributions of $5 million to capital funding. In July 2012 the European Union agreed to provide €5 million for the construction of the magnets of the main ring, under an agreement that CERN will lead the work and provide training for the SESAME staff who will be involved. In addition, Pakistan and the Palestinian Authority have expressed a willingness to make in-kind contributions with values up to $5 million and $2 million respectively, Egypt is very seriously considering providing $5 million (which might well have been agreed by now were it not for frequent changes of government over the last year), and the U.S. government is considering making a significant contribution. Funding is also being sought from charitable foundations, which might be especially interested in supporting the guest house and conference center. If the full $36 million needed from now to the end of 2015 is not available, certain items could be postponed in the interest of bringing SESAME into operation and starting the experimental program at the earliest possible date.

The annual operating budget of SESAME, which is currently $2.3 million, will rise steadily to around $5.3 million in 2017 when SESAME will be fully operational. Increasing the budget by this magnitude over a few years will be difficult for the members, many of whom have very small science budgets. SESAME plans to seek endowments for posts at SESAME or for users at universities in the region that could be associated with SESAME, which would help ensure the success of the project and ease the financial burden on the members.

Outlook

SESAME has faced, and continues to face, major challenges:

- Obtaining the remaining capital funding as well as stable financial support for operating costs, which will not be easy given the low level of science funding in many of the members and unexpected financial difficulties that can arise (e.g., as a result of the cataclysmic floods in Pakistan).
- Attracting additional members, with which UNESCO is helping. Broadening the scientific base of SESAME and sharing the benefits (and the financial burden) more widely would be in everybody's interest. In particular, SESAME hopes to attract more members from the Gulf, the Maghreb, and possibly the Caucasus and Central Asia. However, there is reluctance to join at a time of great political tension in the region.
- Compensating for differences in the financial, scientific, and human resources of the members, which has not proved as difficult as might have been feared. However, the fact that not all are contributing to the capital cost could prove a source of tension in the future. Additionally, scientific disparities could become a problem when it comes to selecting experiments and allocating time with the beam, although the expectation is that collaborative work will serve to iron out differences.
- Solving issues involving travel restrictions, which are a serious problem. The SESAME Council can meet in Jordan without difficulty, but it has not been possible to hold meetings in other member countries except Cyprus, Egypt, and Turkey.

Nevertheless an enormous amount has been achieved thanks to the enthusiasm of scientists in the region, strong support in Jordan (from His Majesty King Abdullah II downwards), the help of UNESCO and IAEA, and the extremely impressive worldwide support for the project, largely inspired by its political aims, in the form of donated equipment and provision of training opportunities and expert advice.

The voluntary contributions (agreed in March 2012) constitute a major step forward and make it possible that commissioning will begin in late 2015. SESAME is working politically and technically, and the training program is building capacity in the region. Political differences are generally forgotten in SESAME meetings. While at times of particular tension hints of differences have very occasionally surfaced, governmental representatives of such unlikely partners as Israel, Iran, the Palestinian Authority, the United States, the United Kingdom, Cyprus, and Turkey, among others, are still able to sit around a table together working constructively for a common goal. Experience from CERN and the atmosphere at SESAME users' meetings provides confidence that, while there may be initial suspicions to be overcome, the users from different member countries won't have any difficulty working together at SESAME.

"Science for peace" only works if the science is truly excellent. My job as president of the council is to ensure that SESAME will be a first-class scientific instrument. If it is, SESAME will attract excellent scientific users from all the member countries and encourage scientists to remain in, or return to, their home region to pursue their research. These scientists will work together to produce first-class science while building personal links that cross political, cultural, and religious boundaries. SD

Endnotes

1. The opinions of some of the people involved on the benefits of SESAME can be found at http://mag.digitalpc.co.uk/fvx/iop/esrf/sesamepeople/.