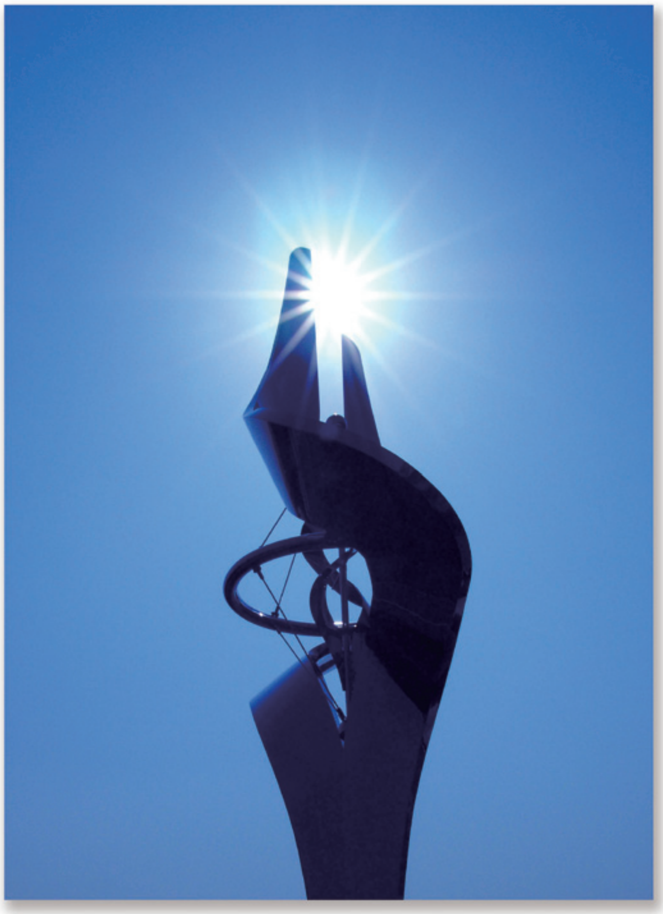
A Place in the "X-ray" Sun

Endeavors at Frontiers of Research



1. Fine Art at SPring-8

The *largest* instrument at SPring-8 is the inelastic X-ray scattering (IXS) spectrometer at BL35XU (Fig. 1). It measures the dynamics of atoms, investigating atomic motions in liquids and glasses, and the relation between phonons and solid-state properties including superconductivity, ferroelectricity and elasticity. Traditionally this has been the domain of inelastic neutron scattering (INS). However, X-rays offer some very significant advantages over neutrons. For disordered materials, a crucial advantage allows X-rays to probe regions of energy and momentum transfer not accessible to INS, and has led to an explosion of research on disordered materials in the last decades. For crystals, the subtle advantages of low background and simplicity (which should never be under-rated) allow phonon measurements essentially as easily as X-ray diffraction. However, perhaps the single biggest advantage of X-rays over neutrons is the *reduction in required sample volume by some 5 orders of magnitude* due to the brilliance of the X-ray source. This makes it possible to consider doing experiments never dreamed of with neutrons, including, for example, investigating phonons in hot new samples, such as MgB_2, now well investigated by IXS (but still not accessible to INS) or the very new iron containing superconductors.

The exquisite design and implementation of the IXS beamline by Baron and co-workers integrates cutting edge instrumentation with the exceptional performance, stability, and the high electron-energy of the SPring-8 storage ring. This year one can find contributions within this volume from the IXS spectrometer, including work on phonons in quasi-crystals (page 78), sound in a metal glass (page 76), and phonons in superconducting diamond (page 82). The metal-glass measurements show the advantages of IXS for disordered materials, the work on superconducting diamond shows the value of IXS for very small sample volumes, while the quasicrystal work is an example of fine art.

"Symmetry" is a common theme in Art, Science and Mathematics. In basic geometry, a plane can be filled periodically by closely packing building blocks with 3-fold, 4-fold, even 6-fold symmetry structure, but not 5-fold "pentagonal" structure (Fig. 2). Thus, about 20 years ago, the scientific community was surprised by the discovery of class of space-filling materials that had 5-fold symmetry. The explanation was that they were not periodic - but only quasi-periodic - having a

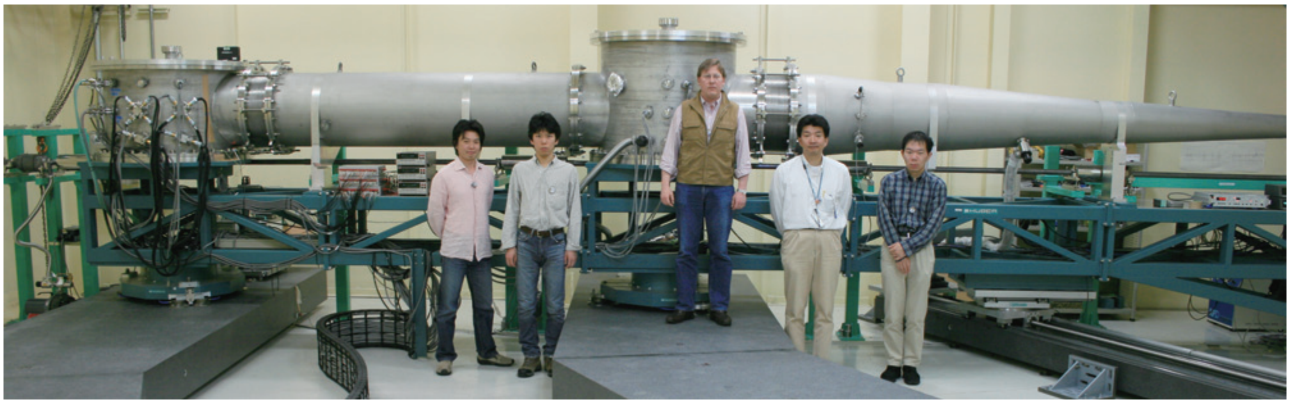


Fig. 1. Alfred Baron's Research Group (JASRI) with high resolution inelastic scattering spectrometer at BL35XU.

structure that repeated, but not with a fixed step size. These beautiful new materials generated artistic and mathematical interest, but also forced a re-examination some basic physical principles, since periodicity is built into the foundations of much of materials science. Their structure is now beginning to be understood with the help of a six-dimensional system for crystallography.

The relevant question is how the symmetry of a quasi-crystal influences the atomic motions. The first part of the answer can be found in [1] as discussed in the contribution on page 78, where inelastic X-ray scattering, inelastic neutron scattering and sophisticated calculations, are used to isolate the effect the quasi-crystal symmetry. In fact, exploring dynamics in unusual symmetries may be the early stage of a fad – note also the work on tiling arrangements in the work on block copolymers using SAXS by Matsushita's group of Nagoya University (see Chemical Science: Mesoscopic tiling patterns of ABC star-shaped terpolymers studied by microbeam small-angle X-ray scattering, page 106).

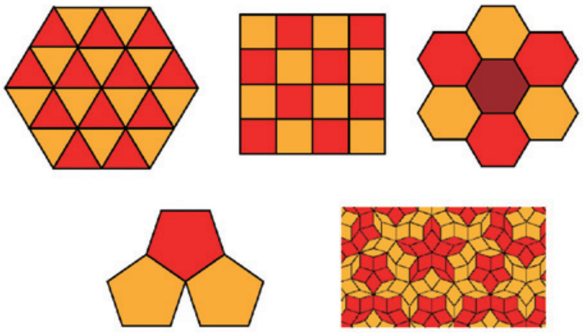


Fig. 2. Close packing of 3, 4 and 6-fold symmetric structures can be used to fill a plane. However, 5-fold structures cannot be stacked that way, one has to introduce an additional shape, and then the plane can be filled without translational symmetry.

[1] Marc de Boissieu, Sonia Francoual, Marek Mihalkovic *et al.*, Nature Materials advanced online publication (2007).

2. Winds of Change

- New type of industrial-academic alliance -

This year, the construction of 4 new beamlines was approved, making a big step toward filling the available synchrotron radiation ports at SPring-8.

Three Contract Beamlines

Frontier Soft Matter Beamline (BL03XU)
(Frontier Soft Matter Beamline Consortium)

University of Tokyo Beamline (BL07LSU)
(Outstation Program of University of Tokyo)

TOYOTA Beamline(BL33XU)
(TOYOTA Central R&D Labs.,Inc)

One RIKEN Beamline

RIKEN Target Proteins Beamline (BL32XU)

In particular, the Frontier Soft Matter Beamline (FSM BL) has a unique consortium organization based on an ***industrial-academic alliance***. The fundamental structure of the consortium consists of 17 corporate groups, including industrial companies and their collaborating academic scientists as shown in Fig. 3. It is also important to note that the Kwansei Gakuin University (private university) join the FSM BL consortium as an independent industry aiming scientist & engineer resource development.

The mission of the FSM BL is to clarify the nano-to-meso scale properties of polymers and soft matter from both industrial and academic points of view. It is aimed at development of next-generation materials for nano- and micro-technology. Construction of the FSM BL will be started in spring of 2008 and it will be opened for the consortium users in the winter of 2009, after commissioning. The academic members will lead the consortium to new science with polymers and soft-matter using synchrotron radiation.

A schematic of the FSM BL is shown in Fig. 4. The first hutch will be used for thin-film structural investigations. The experimental hutch will have systems for time-resolved GIXD and GISAXS to

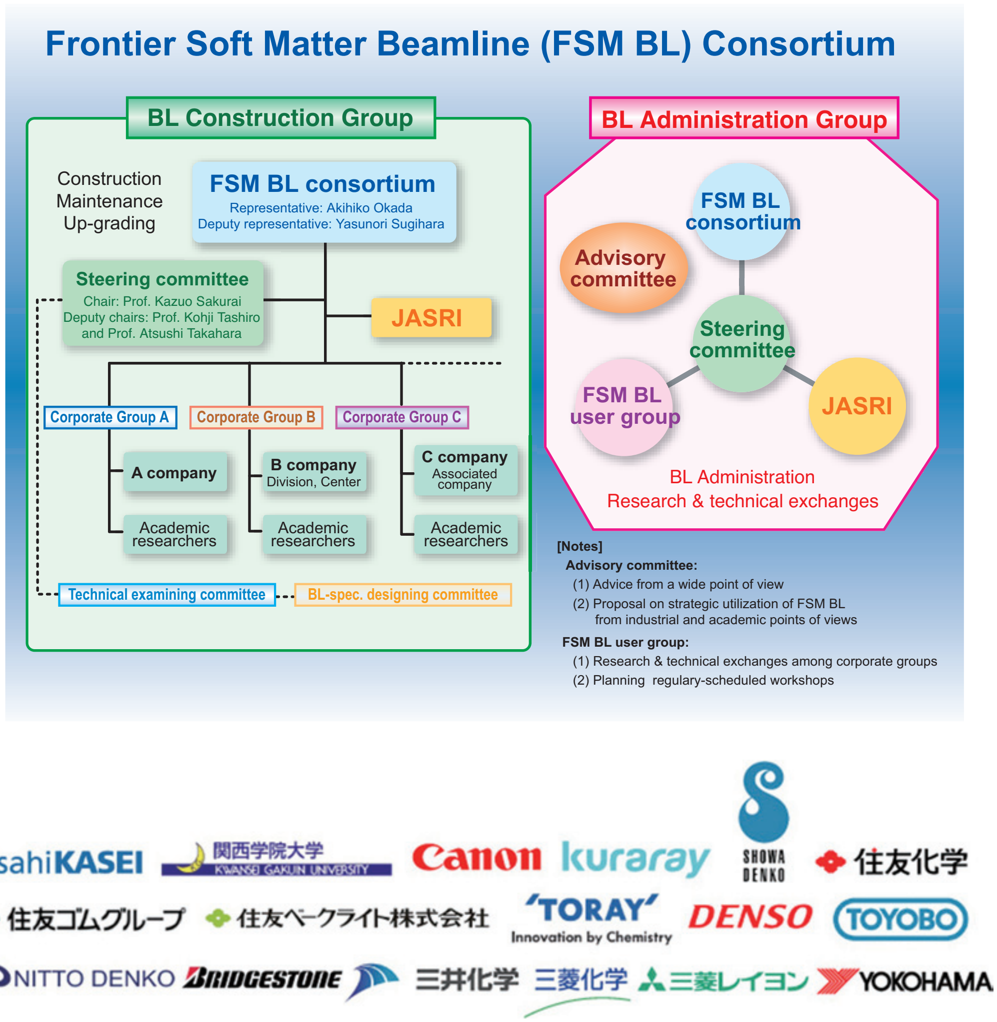


Fig. 3. Organization and participants in the FSM beamline.

conduct measurements on thin films of polymers and soft matter. The second hutch will focus on dynamic nano·meso-structure science. The main specifications of second experimental hutch design are:

- SAXS resolution up to 0.7 μm (1.0 μm).
- Time-resolved WAXS/SAXS measurements and microbeam WAXS and SAXS measurements for bulk samples.
- A large space (3m (l) × 3m (w) × 4 m (h)) for optional equipment at the sample area to conduct new experiments, such as multi-control measurement and manufacturing/processing machine tests.

The planned beamline will bring a wide range of advancements for polymer and soft materials science and their industrial applications. Moreover, the new type of organization, the industrial-academic alliance, will surely create a broad-ranging partnership between industrial and academic communities, bringing new impetus to industrial application of synchrotron radiation.

3. A New Horizon
- Dawn in Asia and Oceania -

The first summer school of the Asia-Oceania Forum of Synchrotron Radiation Research (AOFSRR) was held from 10 to 20 September, 2007, at SPring-8. The AOFSRR was organized in 2006 by the Australian Synchrotron Research Program (Australia), the Chinese Society of Synchrotron Radiation Research (China), the Indus (India), the Japanese Society of Synchrotron Radiation Research (Japan), the National Synchrotron Research Center (Thailand), the National Synchrotron Radiation Research Center (Taiwan), the Pohang Light Source (Korea) and the Singapore Synchrotron Light Source (Singapore). The purpose of the school is to provide useful and

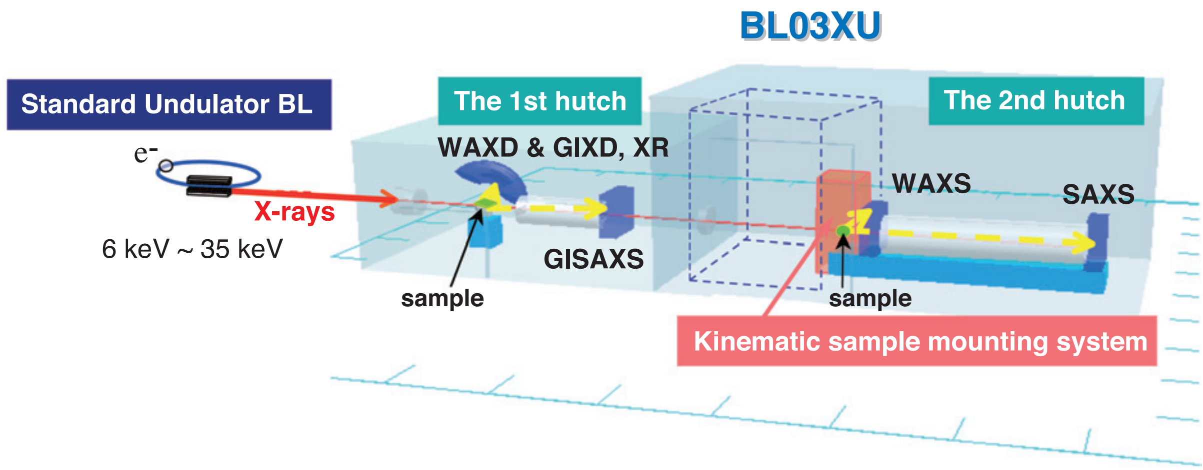


Fig. 4. Schematic of the frontier soft matter beamline (FSM-BL).

basic knowledge, as well as a broad perspective of synchrotron radiation science and technology. It is aimed at graduate students, post-docs, young scientists and engineers in the Asia-Oceania region. Most important is that this summer school should be useful and practical for the Asian Oceania SR facilities. Thus, the school curriculum includes a round table discussion, ***"Meet The Experts,"*** where the students can consult experts for their own problems in SR science, and a practical section, ***"BL Practice."***

The ***Cheiron School*** is named after an immortal gods in Greek mythology who specialized in providing the right knowledge or skill to the right person: Cheiron taught martial art to Hercules, medicine to Aesculapius, horsemanship to Castor, etc. The policy of the school is similar, aiming to teach the needed skill to the right person. It is an important tool to develop engineers and scientists as a resource for synchrotron radiation research in Asia-Oceania region. The ***Cheiron School*** will promote a "person-to-person" network in Asian/Oceania synchrotron radiation community. Further details can be found at http://cheiron2007.spring8.or.jp/index.html.

Masaki Takata

Fig. 5. Poster and school photo of Cheiron School.

Table 1. List of the lecturers

SUBJECT	LECTURER
Overview of SR	Robert N. Lamb (Australian Synchrotron)
Light Source 1&2	Takashi Tanaka (RIKEN)
History of SR	Taizo Sasaki (Japan)
X-ray Monochromator	Shunji Goto (JASRI)
Mirror and Multilayer	Christian Morawe (ESRF)
Micro-focusing Optics	Barry Lai (APS)
Next Generation Sources	Tsumoru Shintake (RIKEN)
Accelerator Physics (Linac)	Yujiro Ogawa (KEK)
Accelerator Physics (Ring)	Greg LeBlanc (Australia)
Diffraction and Scattering	Brendan Kennedy (Univ. of Sydney)
Powder Diffraction	Brendan Kennedy (Univ. of Sydney)
Photoemission(2): PEEM and nanoscience	Bruce Cowie (Australian Synchrotron)
Spectra -a Synchrotron Radiation Calculation Code-	Takashi Tanaka (RIKEN)
Inelastic X-ray Scattering	Ercan Alp (APS)
Protein crystallography	Soichi Wakatsuki (KEK)
Photoemission(1): Spectroscopy	Nobuhiro Kosugi (UVSOR)
VUV & SX Optics 1&2	Takeshi Namioka (Tohoku Univ.)
Detector	Chris Hall (Monash University)
Soft X-ray Absorption Spectroscopy and Resonant Scattering	Di-Jing Huang (NSRRC)
Imaging	Chris Hall (Monash University)
Small-angle Scattering	Moonhor Ree (PAL)
Atomic and Molecular Physics	Akira Yagishita (KEK)
EXAFS	Iwao Watanabe (Ritsumeikan Univ.)
Pump-Probe Experiment	Shin-ichi Adachi (KEK)
Industrial Applications	Norimasa Umesaki (JASRI)
X-ray Fluorescence Analysis	Atsuo Iida (KEK)
LIGA	Linke Jian (SSLS)
High pressure/High temperature	Osamu Shimomura (KEK)
Infrared	Mark Tobin (Australia)
New Scientific Possibilities and Directions	Tetsuya Ishikawa (RIKEN)

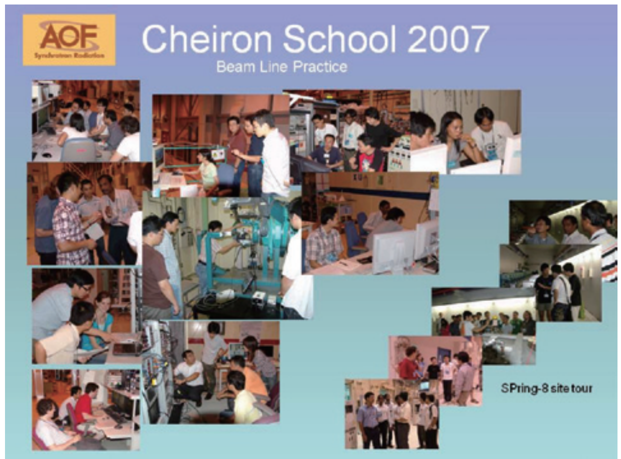


Fig. 6. Practical session.


Fig. 7. Excursion to the Imperial Palace in Kyoto.