SIMULATING THE EARLY SOLAR RADIATION ENVIRONMENT:
X-RAY RADIATION DAMAGE EXPERIMENTS

H. Lammer(1), A. Hickel(2), M. G. Tehrany(1,3), A. Hanslmeier(3),
I. Ribas(4,5) and E. F. Guinan(5)

(1) Space Research Institute, Austrian Academy of Sciences, Schmiedlstr. 6, A-8042 Graz, Austria
Phone: +43 316 4120641, Fax: +43 316 4120690, Email: helmut.lammer@oeaw.ac.at
(2) Institute for Biophysics and X-Ray Structure Research Austrian Academy of Sciences
Schmiedlstr. 6, A-8042 Graz, Austria, Email: andrea.hickel@oeaw.ac.at
(3) Institute for Meteorology, Geophysics and Astrophysics, University of Graz
Universitätsplatz 5, A-8010 Graz, Austria, Email: mehrdad.tehrany@assoc.oeaw.ac.at
(4) Departament d’Astronomia i Meteorologia Universitat de Barcelona, Av. Diagonal 647, 08028 Barcelona, Spain
(5) Department of Astronomy and Astrophysics Villanova University, Villanova, PA 19085, USA

ABSTRACT

Astrophysical studies inside the “Sun in Time” program indicate that solar-type young stars underwent highly active phases. The studied stars are single G-type stars with ages ranging from 70 million years to 9 billion years and have X-ray luminosities ranging from 1 to 1000 times that of our quiet Sun. Therefore, the proto-planetary nebula and after planetary formation the gas, dust, comets and meteoroids which travelled through interplanetary space were exposed during the period of the heavy asteroid bombardment by these large X-ray fluxes. Such high X-ray intensities should have affected the organic chemistry in the planetary nebula, organic molecules on comets, meteorites and asteroids. For getting an idea how the large X-ray fluxes or present solar Flares may have affected organic or inorganic matter in the early solar system, we plan to expose samples with comparable short wavelength radiation in the laboratory.

1. EARLY SOLAR SYSTEM RADIATION ENVIRONMENT

The “Sun in Time” program is a multi-wavelength study of the magnetic activity of single G0–V stars selected solar proxies for our Sun at several stages of its main sequence lifetime [1]. The youngest star selected in this study is EK Dra and has an age of about 0.13 Gyr. This time was shortly after the Sun arrived on the zero age main sequence. The oldest star in the program is 16 Cyg A with an age of about 8.5 Gyr, which is close to the terminal age main sequence for stars with 1 solar mass. A huge dataset from the satellite data included in Table 1 is currently analysed and will be brought in a context, which can be used for the input of simulated exobiological relevant exposure experiments in a laboratory.

Table 1. Satellite data currently under study inside the Sun in Time program.

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Wavelength</th>
<th>Calibration method</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASCA</td>
<td>1-40 Å</td>
<td>Multi-Te plasma model</td>
</tr>
<tr>
<td>ROSAT</td>
<td>6-124 Å</td>
<td>Multi-Te plasma model</td>
</tr>
<tr>
<td>EUVE</td>
<td>80-760 Å</td>
<td>Flux calibrated</td>
</tr>
<tr>
<td>FUSE</td>
<td>920-1180 Å</td>
<td>Flux calibrated</td>
</tr>
<tr>
<td>IUE</td>
<td>1150-3300 Å</td>
<td>Flux calibrated</td>
</tr>
<tr>
<td>UBVRHKL+</td>
<td>3300-20000 Å</td>
<td>Flux transformations</td>
</tr>
<tr>
<td>Kurucz</td>
<td></td>
<td>Distance corrections</td>
</tr>
</tbody>
</table>

2. SPECTRUM OF SOLAR PROXIES WITH DIFFERENT AGES

The data in Fig. 1 show that while the NUV/optical flux is similar for all stars, very large differences exist in the high-energy portion of the spectrum. Over the past decade, data covering X-ray, EUV, FUV, NUV and optical wavelengths that cover coronal emissions and chromospheric emissions were secured. These data show that the young Sun was completely different in the short wavelength region. Further the observed high X-ray luminosities of these young solar proxies implicate also a high stellar Flare rate. This could result in Coronal Mass Ejections observed on the Sun today, but much stronger and more frequent.


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To radiate various biological samples over a large area, this set-up needs to be optimised to get a maximal possible area of radiation. The sample holder will be constructed for the use of solid samples fixed on a carrier (e.g. Uracil-powder, planetary surface analogue materials, dust analogues, etc.), as well as of liquid suspensions (e.g. bacterial suspensions). To avoid damage by secondary radiation the experiments will be carried out under vacuum.

**CONCLUSION**

It is expected that in the future, exobiology research in Low Earth Orbit (LEO) and on other planets in our solar system will play a major role in ESA’s Life and Physical Sciences Programmes ELIPS and AURORA. The experiments involved in the EXPOSE-facility on board of the ISS will provide new research data on the survivability of organic molecules and microorganisms during long-time exposure with extraterrestrial radiation, but do not consider higher X-ray and EUV emissions as discussed above, since the samples are exposed to the current solar radiation environment. Therefore, our planned experiments can add to these studies by simulating the early solar radiation environment or energetic solar Flares. Further our research is also extremely important to study the emission of dangerous short-wave radiation, which will be hazardous to manned space missions and biological systems in general.

**REFERENCES**


Fig. 1. Data of 5 solar-like stars from the “Sun in Time” program with an age from 0.13 Gyr to 6.7 Gyr. One can see that the young stars representing the early Sun have 1000 times higher soft X-ray fluxes.

3. **EXPERIMENTAL SET-UP**

Our planned X-ray - radiation damage experiments will be performed in a radiation chamber especially designed for this purpose. The SWAX (SWAX, Hecus-MBraun-Graz-Optical Systems, Graz, Austria) system normally used at the Institute for Biophysics and X-Ray Structure Research (IBR) is constructed to get maximal scattering of the X-rays under optimal conditions. This means that the X-ray beam is collimated in this system to a rectangular profile of 20 x 1 mm.

![Diagram of experimental set-up](image)

Fig. 2. Experimental set-up of the soft X-ray damage experiments.