Joachim E. Trümper

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In his PhD work (1957-59) at the Universities of Hamburg and Kiel, Joachim Trümper developed the first triggered spark chamber, a forerunner to the spark chamber which was widely used later in high energy physics. Using these spark chambers in a magnetic spectrometer he measured (together with O.C. Allkofer) the Cosmic Ray Muon Spectrum on the Zugspitze (1960).

In the early 60ies J. Trümper became interested in very high energy cosmic rays (10^{14} – 10^{17} eV). As the leader of a group of young scientists and students, he initiated the Kiel extensive air shower experiment which aimed at solving the problems of the chemical composition of cosmic rays in the "knee region". A very popular view at that time was that the observed break ("knee") in the cosmic ray spectrum was due to a rigidity cutoff in the storage capacity of the galaxy which would lead to a change of the chemical composition of cosmic rays in the break region. Although the goal could not be achieved[1] the experiment yielded a number of interesting results, in particular on the hadronic structure of air shower cores.

After the discovery of pulsars in 1967 J. Trümper turned his attention to this new field. Using the Gunn-Ostriker model of particle acceleration in the wave zone of highly magnetized rotating neutron stars he showed that the curvature radiation emitted by the electrons and positrons might be responsible for the pulsed emission of the Crab pulsar observed in the optical, X-rays and gamma rays. This and other related work was performed during a sabbatical leave from Kiel which J. Trümper spent in 1969/70 at the Max-Planck-Institut für extraterrestrische Physik (MPE) following an invitation by R. Lüst and K. Pinkau. During this time he decided to start a program of observational X-ray astronomy in Germany. The opportunity to realize this plan came in 1971 when he became Director of the Astronomical Institute of the University of Tübingen (AIT). Leading a group of young scientists (R. Staubert et al), he initiated a hard X-ray balloon program (20-200 keV) which became soon very competitive on the international scale. After his appointment (1975) as Director the Max-Planck-Institut für extraterrestrische Physik (MPE) in Garching, the balloon observations were continued in collaboration between MPE and AIT. Highlights of these activities were the first precise measurement of the thermal bremsstrahlung spectrum of the cataclysmic variable AM Herculis and the first precise measurement of the hard X-ray spectrum of the black hole candidate Cyg X-1 showing the existence of a break in the spectrum. In cooperation with R.A. Sunyaev the spectrum was interpreted in terms of unsaturated Comptonization of photons taking place in a high temperature plasma.

The most important discovery, however, which J. Trümper and his associated made during these early years, was that of sharp and intense spectral feature at *hv* ~ 40 keV (in absorption, or ~ 53 keV in emission) in the hard X-ray spectrum of the binary neutron star Hercules X-1. J. Trümper recognized that the feature was much too strong to be explained by a nuclear line or an atomic line of heavy elements (e.g. of the hydrogen like platinum ion) in view of the low cosmic abundance of such

[1] It is interesting to note that in 2003 the problem is still unresolved despite many investigations which have been done during the last 35 years.

elements, and proposed that it represents the electron cyclotron resonance, corresponding to transitions of electrons between Landau states in the super-strong magnetic field of the neutron star. The corresponding magnetic field is $B \sim 5 \times 10^{12}$ G. Further balloon investigations, in particular phase dependent X-ray spectroscopy, confirmed the interpretation in terms of a cyclotron absorption line. Such spectral lines had never been found before in any star, and they are generally not expected because the magnetic field in a stellar atmosphere is rather inhomogeneous leading to a smearing of the cyclotron resonance frequency. However, in the case of a strongly magnetized neutron star like Hercules X-1, the matter accreted from its companion is magnetically channelled onto the magnetic poles, where relatively small hot spots are formed. At temperatures of $\sim 10^{8}$ K indicated by the continuum spectrum, electrons are the most abundant species, and their motion transverse to the magnetic field is subject to the Landau quantization. The resulting cyclotron line is sharp because the magnetic field is

rather homogeneous across the small spot. Actually, J. Trümper derived limits on its spatial extent from the observed line width.

The discovery of cyclotron lines has not only provided the first direct measurement of a neutron stars magnetic field. It has also stimulated a large amount of theoretical work on interactions of electrons and photons in super-strong magnetic fields, and on atomic physics in a regime, where Lorentz forces are much stronger than Coulomb forces. The discovery has also spurred the search for other accreting neutron stars showing cyclotron lines. About a dozen more have been found so far.

As a follow-up to the balloon project the MPE/AIT group (C. Reppin et al) developed a hard X-ray spectrometer (HEXE) for the international broad band X-ray observatory aboard the Mir Station, which has been in operation from 1987 until the re-entry of the station. One of the highlights of this mission was the discovery of hard X-rays half a year after the explosion of SN 1987A which result from Ni^{56}/Co^{56} gamma rays undergoing Comptonization in the expanding shell. In addition the experiment contributed significantly to our knowledge about the hard X-ray spectra of X-ray binaries, in particular of black hole transients.

As early as 1972/73 J. Trümper initiated experimental activities at the University of Tübingen aiming at the construction of large imaging X-ray telescopes in collaboration with Carl Zeiss. This program resulted in two major technological breakthroughs: (1) the demonstration that Zerodur despite its microcrystalline structure can be used to build high performance X-ray optics and (2) the reduction of the mirror surface roughness to an unprecedented level, namely 2.5 Angstrom (for comparison: Einstein observatory ~ 20 Å).

In 1975, around the time when he joined MPE, J Trümper proposed an early version of ROSAT as an element of the German Space Programme. After extensive instrument development and industry studies the Project was internationalized in the early eighties leading to the well-known German-US-UK ROSAT project, for which J.Trümper acted as principal investigator and director of the observatory. The focal instrumentation of the ROSAT telescope including the two main detectors (PSPC's) were designed and built by MPE (E. Pfeffermann, H. Hippmann et al). In order to facilitate the mirror and telescope testing as well as calibration MPE built a powerful long beam X-ray test and calibration facility H.Bräuninger et al.) which not only played a crucial role for ROSAT but also for EXOSAT, Beppo-SAX, Chandra, XMM-

Newton and other projects. ROSAT was launched in June 1990 and operated until February 1999. The main ROSAT Science Data Centre was and still is located at MPE (U. Zimmermann, W. Voges et al).

ROSAT observations had a strong impact on many fields of astrophysics, as evidenced by the large number of scientific publications (more than 5.000) which appeared so far. Its success strongly facilitated the integration of X-ray astrophysics into astronomy in general. The ROSAT all sky survey presented a unprecedented detailed view of the diffuse soft X-ray emission from the Galaxy including many supernova remnants. The total number of discrete source in the survey is ~ 125.000 (compared with 840 of the preceding HEAO-1 survey). Another 80 – 100.000 fainter X-ray source have been detected in the ~ 9.000 fields of pointed observations which led to many discoveries.

J. Trümper was personally involved in a number of ROSAT discoveries and highlights, which include:

1. The X-ray picture of the moon taken in 1990 showed not only the scattered solar coronal X-rays but also the first “X-ray shadow” cast by the moon on the X-ray background.

2. In the early ROSAT phase the super-soft X-ray sources were discovered as a new class by J. Trümper et al in the LMC, SMC and M31, which turned out to be the long-sought class of cataclysmic variables showing steady nuclear burning on the surface of the white dwarf.

3. Another field of scientific activity of J. Trümper was the observation of single neutron stars: radio pulsars, point sources in supernova remnants (SNR) and single neutron stars which are not connected with a SNR or pulsar. In the course of this work a few dozen single neutron stars were discovered and it became possible to distinguish between the beamed magnetospheric and the quasi-isotropic thermal emission from the hot neutron star surface. During the last few years J. Trümper concentrated on the scientific analysis and interpretation of Chandra and XMM-Newton observations of single neutron stars. The perhaps most important result has been the discovery that the neutron star RXJ 1856-3754 reveals a completely featureless Planckian-like spectrum in which all characteristic absorption features of a photosphere are missing.

4. J. Trümper was also involved in the discovery of X-rays from Comet Hyakutake in 1996 which came as a surprise for many astrophysicists. In the meantime about a dozen of comets have been detected, mainly with ROSAT, and it has become evident that emitted X-rays are produced by solar wind ions after undergoing charge exchange in the Cometary coma and subsequent de-exitation.

5. In the mid eighties, long before the ROSAT launch, J. Trümper initiated a ROSAT deep survey project together with R. Giacconi and M. Schmidt. He asked G. Hasinger, a young MPE postdoc at that time to join the team who gradually became the driving force and leader of this long term project . The goal was to solve the old problem of X-ray astronomy, the origin and nature of the diffuse X-ray background (the “holy grail of X-ray astronomy”). The ROSAT deep and ultra-deep surveys showed that the extragalactic background at ~ 1

keV is mainly produced by discrete sources ($\geq$ 80%), and subsequent optical identifications revealed that they were mainly quasars and other types of AGN. A comparison between the ROSAT deep, medium deep and all sky surveys also shed new light on the evolution of the AGN luminosity function out to high redshifts.

Preparations for the post-ROSAT era began at MPE already in the mid eighties: P. Predehl et al. developed the Low Energy Transmission Gratings for AXAF (now Chandra) in collaboration with the SRON group at Utrecht. Another big project was and is the ESA cornerstone XMM-Newton. MPE assumed the scientific responsibility for the XMM-Newton mirror system whose 174 shells provide a large throughout (PI: B. Aschenbach, MPE). Another major activity was the development of X-ray CCD's which are optimised for the scientific goals of XMM-Newton (large field of view, good spectral resolution over a broad band (0.1-10 keV) and millisecond time resolution). To this end J. Trümper founded a dedicated semiconductor laboratory (L. Strüder et al) in collaboration with the Werner Heisenberg Institute. A novel CCD detector fabricated in this high-tech laboratory is not only one of the key instruments on XMM-Newton launched in December 1999. It also will be the heart of ROSITA, a proposed national German project aiming at a X-ray CCD all sky survey extending the successful ROSAT survey to higher energies.

After his retirement from the directorship at MPE Joachim Trümper is continuing his scientific work at this institute.