High Resolution X-Ray Spectra
A DIAGNOSTIC TOOL OF THE HOT UNIVERSE

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XMM-NEWTON ESAC
XMM-Newton & RGS

The Reflection Grating Spectrometer:
- Reflection gratings
- Dedicated CCD detectors
- Each photon position and energy arrival time
- High resolving power
- Range from 7 to 38 Å (~0.33 to 2.5 keV)

XMM-Newton (1999):
- 3 X-ray telescopes
- 58 Wolter I mirrors
- Focal length 7.5 m
- High effective area
- Long exposures
- 2 Reflection Grating Spectrometers
RGS DESIGNED TO DETECT SEVERAL X-RAY EMISSION & ABSORPTION LINES

- **K-SHELL TRANSITION**
- **HELIUM-LIKE TRIPLETS**
  - Carbon, Nitrogen, Oxygen, Neon, Silicon, Argon
- **L-SHELL TRANSITION OF IRON**

![Graph of X-ray spectra showing diagnostic tools to study the X-ray sources](image)
RGS Spectra

Simultaneous Observation with All Instruments

18000 RGS Spectra

9000 Observations
1. Identification of useful Spectra

2. Classification of RGS spectra: Based on spectral characteristic

3. Investigation of physical nature of objects: Physical condition and chemical composition

4. Detailed analysis of typical spectra for each type of objects
Method: DEFINING USEFUL SPECTRA

FITTING GAUSSIAN FUNCTION TO CROSS-DISPERSION PROFILE

Seyfert 1 Galaxy

Defining „minimum usability” parameters

FWHM [ARCSEC] 20.26 ± 0.21
PEAK [COUNTS] 6409.27 ± 56.20
CENTER [ARCSEC] 12.92 ± 0.09
Results: FWHM Distribution

- FWHM > 3 ERROR
- FWHM > 13 [arcsec]
- PEAK > 3 ERROR
- -100 < CENTER < 100

USEFUL SPECTRA ~ 20%
Object Types Distribution

**MOST FREQUENT OBJECTS IN THE SAMPLE**

- **3124 spectra**
  - RGS1 & RGS2
  - Seyfert 1 Galaxies
  - LMXB

- **232 spectra**
  - RGS1 & RGS2
  - Supernova Remnants
  - Pulsars

- **102 spectra**
  - RGS1 & RGS2
  - Supernova Remnants
  - Clusters of Galaxies
Narrow Line Seyfert 1 Galaxies: MCG −6-30-15 & Mrk 766

Disk-line emission interpretation

Model consisting of:
- Absorbed power-law
- Emission lines (gravitationally redshifted and broadened by relativistic effects in a medium of a black hole)
- Components of narrow absorption

Both galaxies identical spectral structure

Emission lines: H-like Lyα lines of O VIII, N VII, C VI

(Branduardi-Raymont et al. 2001)
Low-mass X-ray Binary: EXO 0748–67

Highly variable - Deep eclipses - 3.82 hour orbital period – Inclination 75°–82° - Neutron star

Previous observation - limited spectral resolution
The RGS spectrum - absorption and emission

Bright emission lines:
O VIII Lyα, O VII He-like complex

Weaker emission lines
(the periods of low emission):
Ne X Lyα, Ne IX He-like complex, N VII Lyα

Photoelectric absorption edges
(periods of rapid variation):
O VIII, O VII

(Cottam et al. 2001)
**Extended Sources**

**SUPERNOVA REMNANTS: CASSIOPEIA A**

Detected lines in the spectrum:

Highly ionized species of

Si, Mg, Ne, Fe L, O

Spectra from three regions the N, NE and SE.

RGS extracted dispersed monochromatic images:

The O VIII Lyα and Lyβ lines – maps

Three blobs: E and N rim of the remnant.

(Bleeker et al. 2001)
Clusters of Galaxies: Abell 1835

A luminous X-ray emitting cluster of galaxies – with medium redshift (z = 0.2523)

Studying the RGS spectrum:
- the relative emission measure of cold gas
- the spectral properties of the cooling flow

Detected above the bremsstrahlung continuum:
- 2 Fe L complexes (Fe XXIV lines)
- O VIII Ly α

Fe XXIV ion → cool gas (1 and 3 keV)
O VIII → both cool (1 keV) and hot gas (10 keV)
No other Fe L shell ions → cooling-flow models

(Peterson et al. 2001)
Catalogue of useful RGS spectra

For different types of objects

Atlas characteristic of:

Spectra
Images
Light curves

(Accessible through the Web)
Thank you for your attention!