High Resolution X-ray Spectra

The Glory and the Grandeur

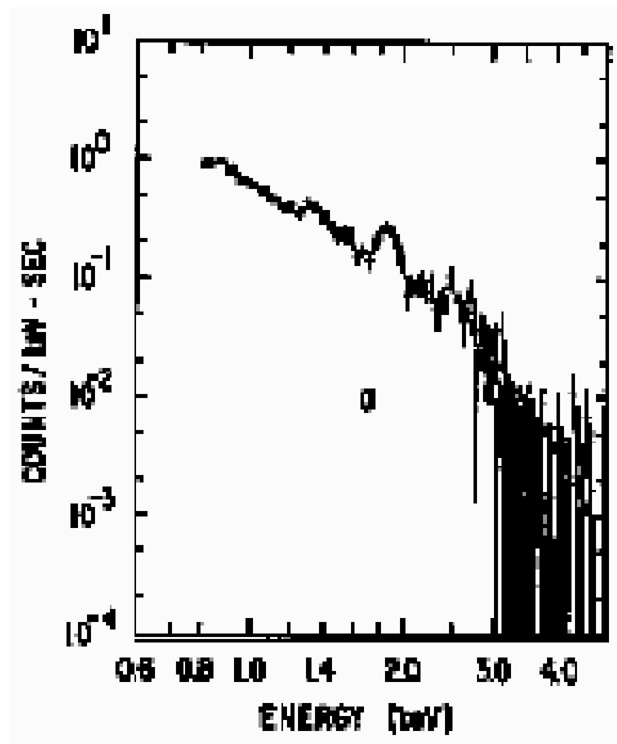
Randall K. Smith

Chandra X-ray Center

Introduction

It has been said that Chandra and XMM/Newton have finally brought high-resolution spectra to X-ray astronomy, but this is not strictly true.

Chandra & XMM/Newton have made high-resolution spectra common, but the first high-resolution spectra to be published was:

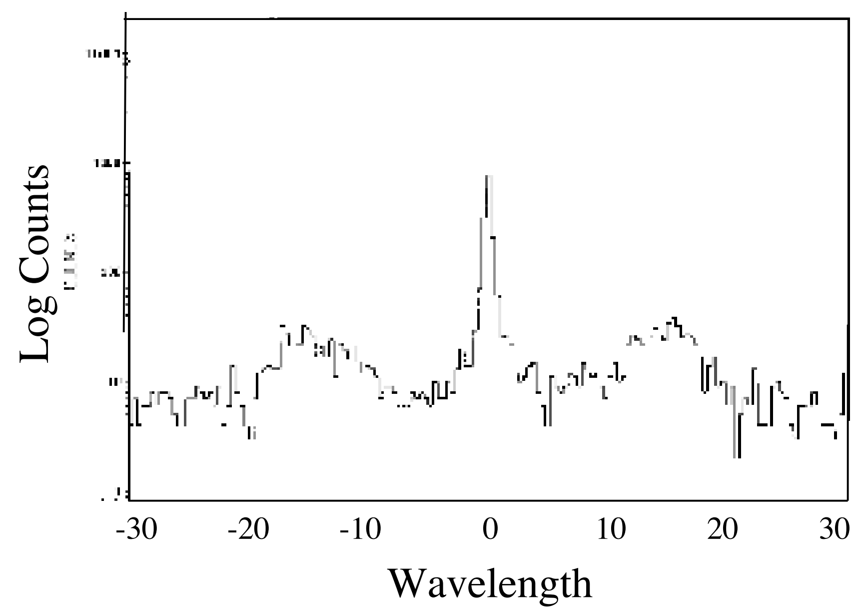


A 7 ksec exposure of Capella with the *Einstein* Solid State Spectrometer (SSS) (Holt *et al.* 1979)

Introduction

Of course, it could be argued that the Einstein SSS is not really high-resolution; it is only ~ CCD resolution. The first published grating spectrum was:

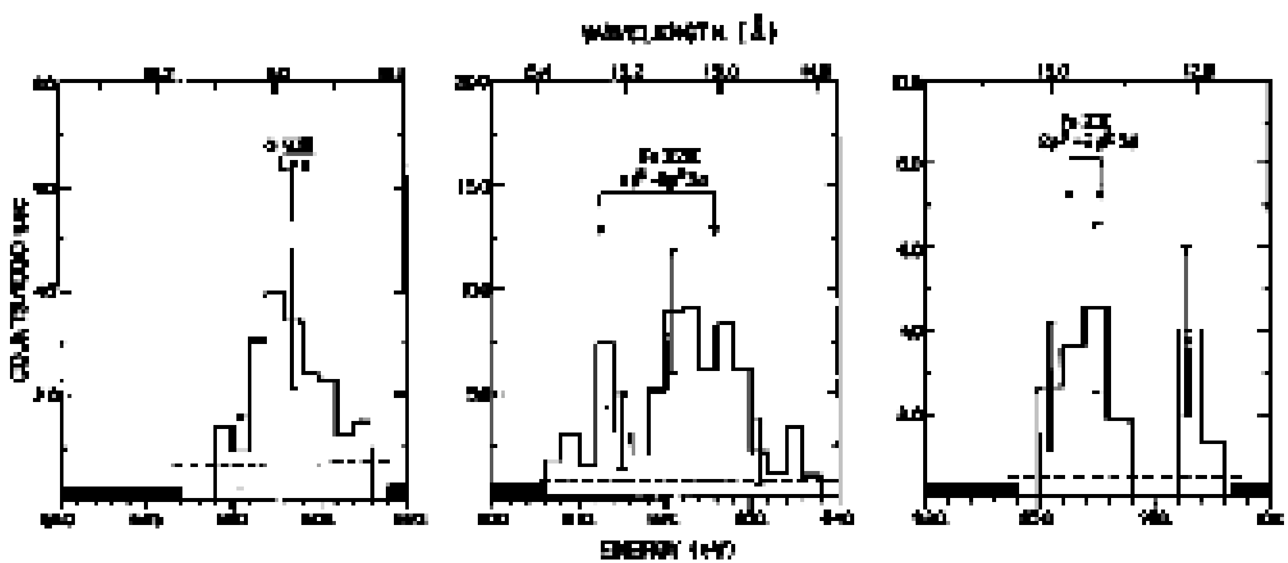
A 42 ksec observation of **Capella** with the Einstein Objective Grating Spectrometer (OGS) by Mewe *et al.* (1982)



Introduction

Close on their heels with an even higher resolution spectrometer was:

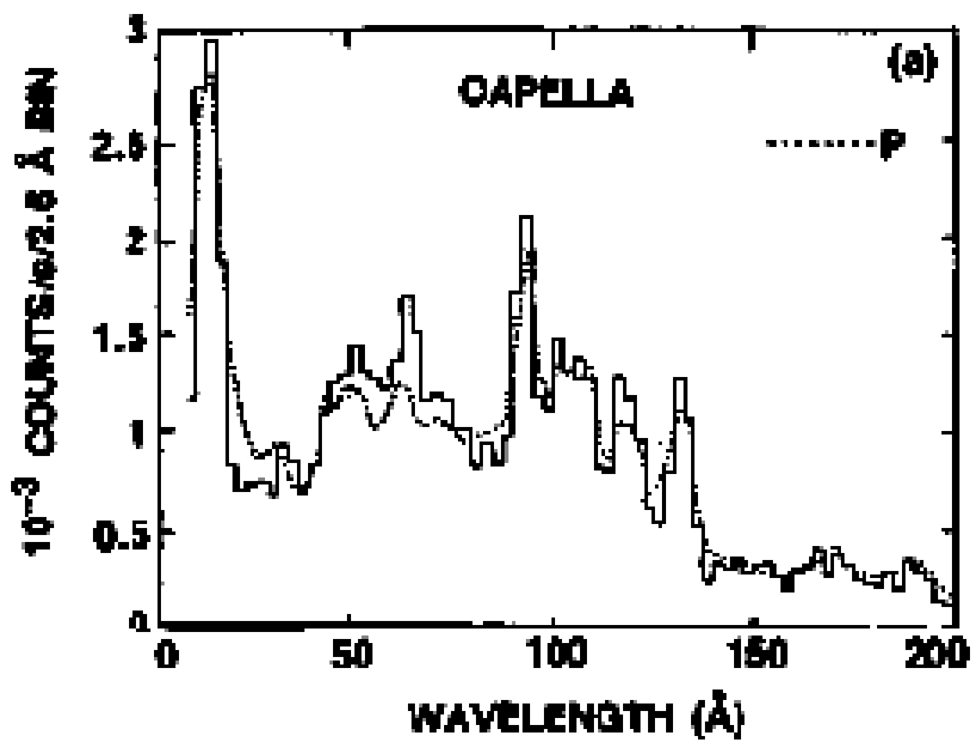
Vedder & Canizares (1983) with a 59 ksec observation of (yes!) **Capella** with the *Einstein* Focal Plane Crystal Spectrometer (FPCS) :



Introduction

After the *Einstein* mission, EXOSAT was launched. Although it primary claim to fame is timing, it did manage to get a high resolution spectrum of:

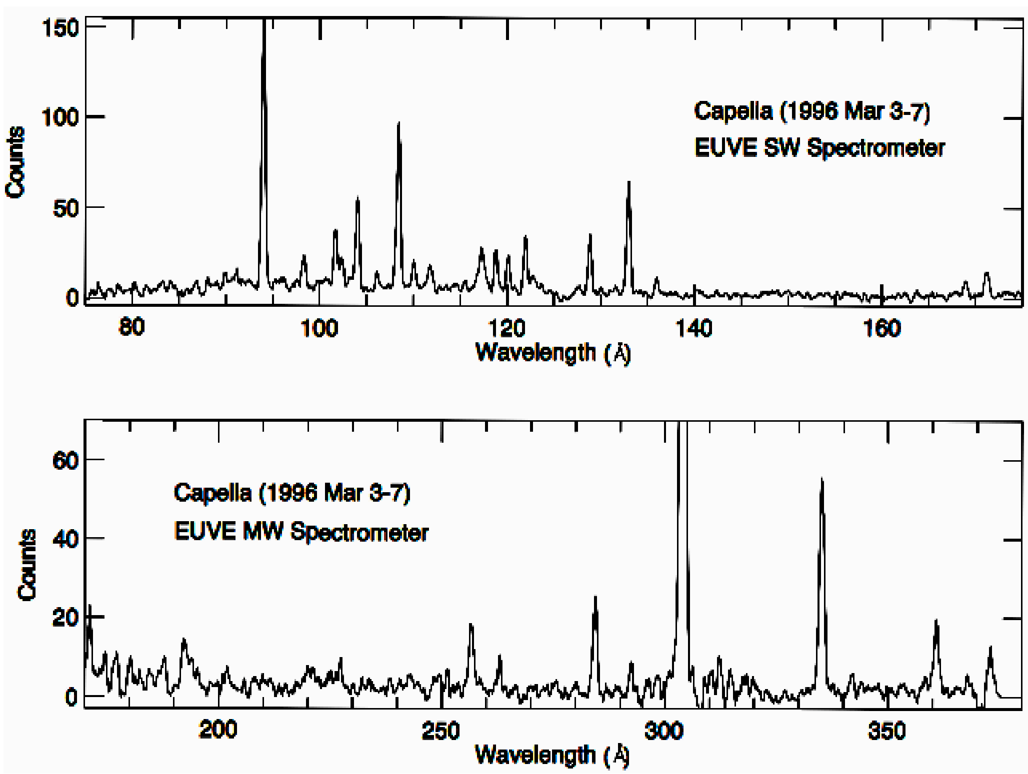
Capella, using the Transmission Grating Spectrometer (TGS) in a 85 ksec observation (Lemen *et al*. 1989)

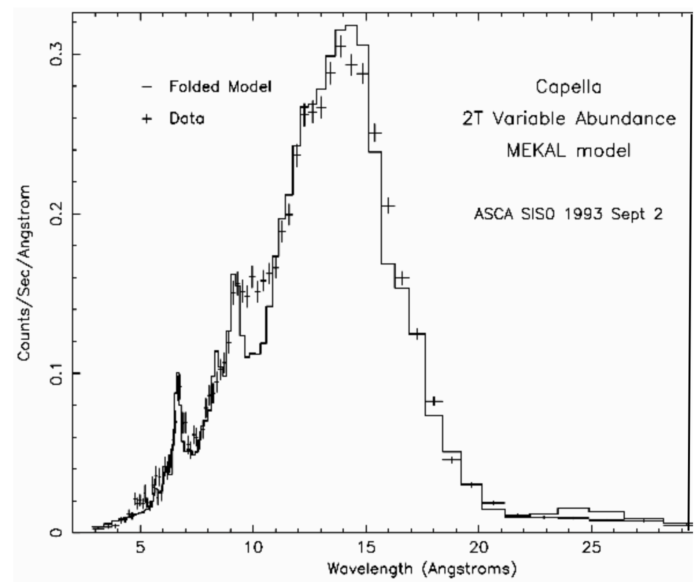


Introduction

Coming into the more modern era (i.e., when I started in this business), there was a joint analysis of EUV/X-ray emission from:

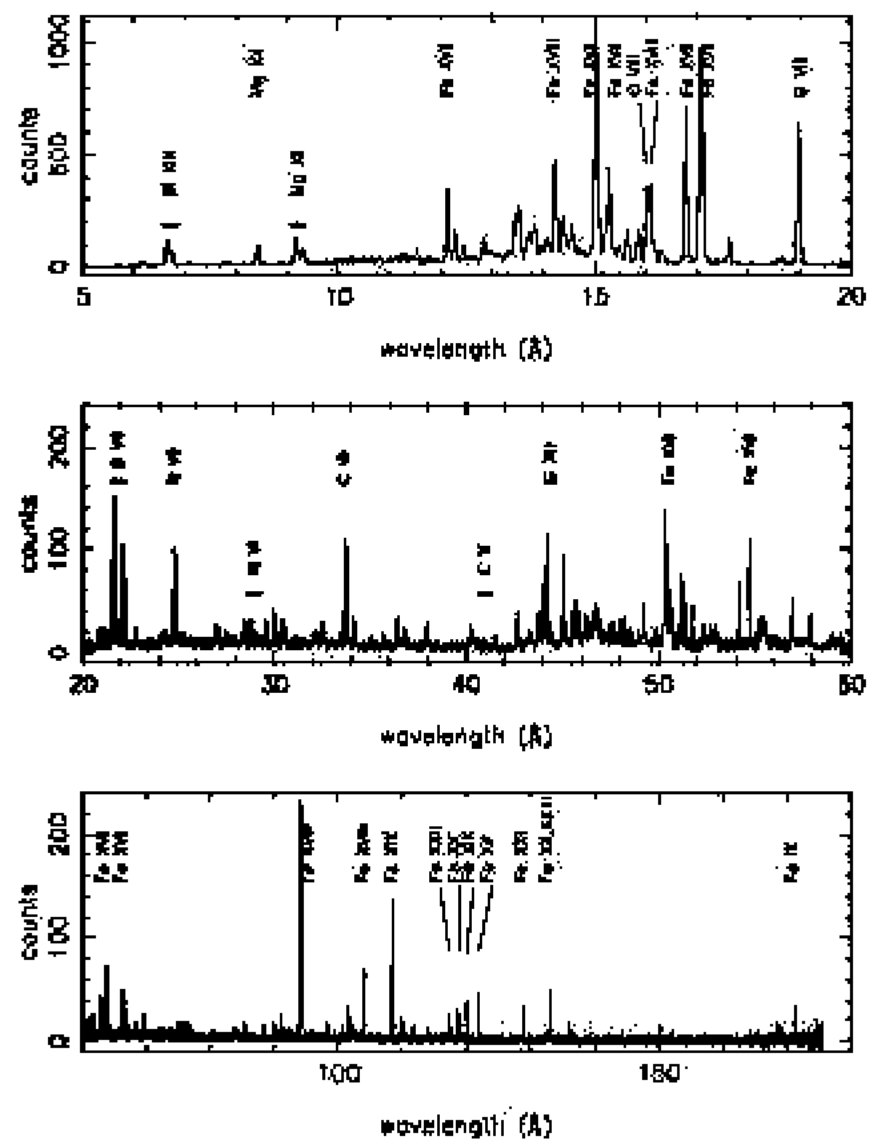
Capella, using a 21 ksec with the ASCA Silicon Imaging Spectrometer (SIS) and a 120 ksec with the EUVE spectrometer (Brickhouse *et al*. 2000)





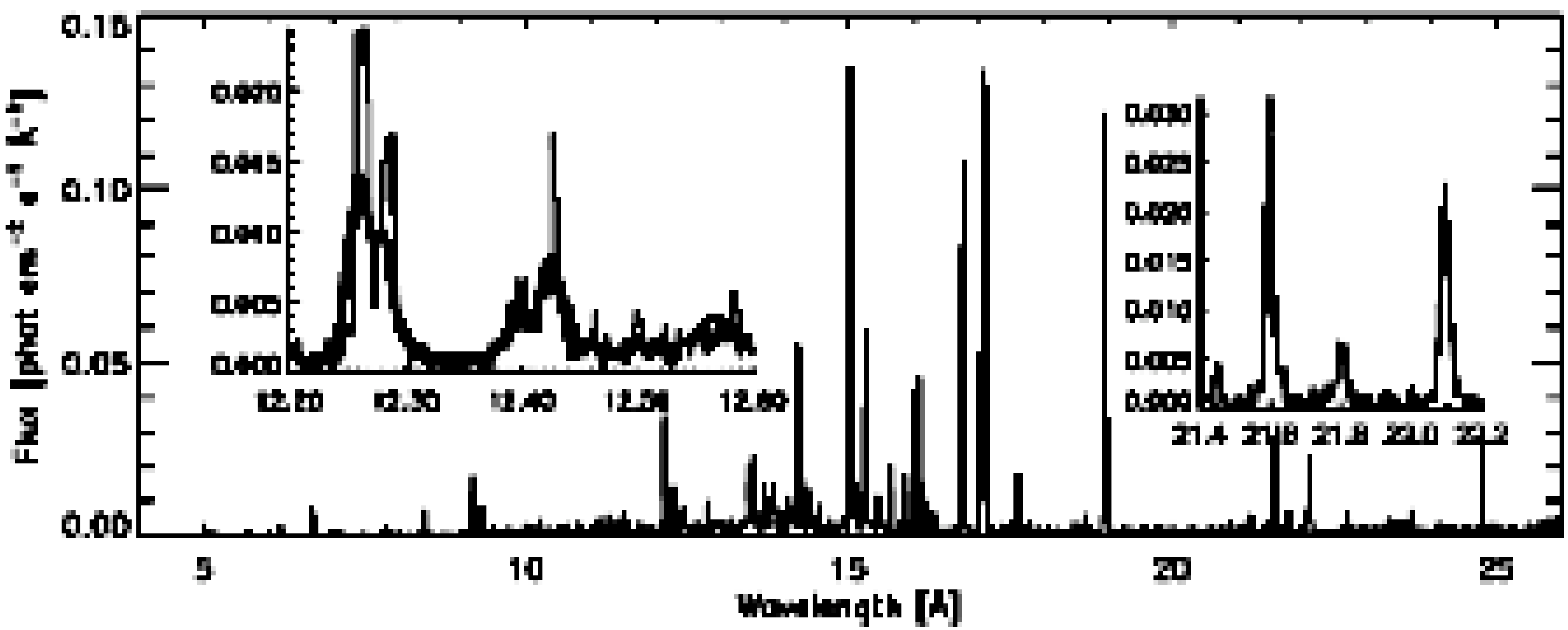
Introduction

Once *Chandra* was launched, two new gratings became available. Here is spectrum of observed for 95 ksec with the Low Energy Transmission Grating (LETG) using the High-Resolution Camera (HRC) as a detector. (Brinkman *et al*. 2000)



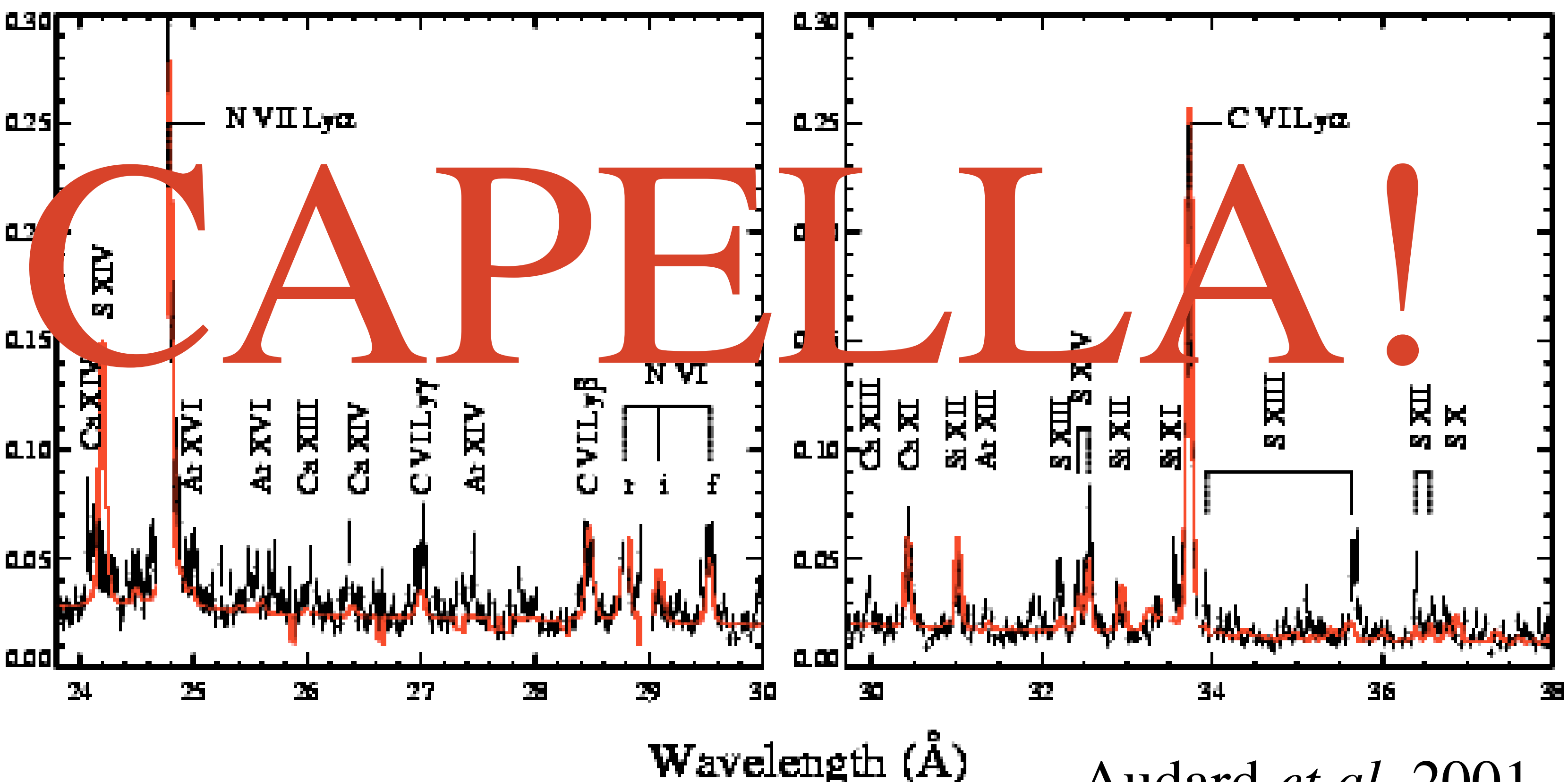
Introduction

And, of course, the High-Energy Transmission Grating (HETG) also observed Capella, with the Advanced CCD Imaging Spectrometer (ACIS) for 89 ksec (Canizares *et al*. 2000)



Introduction

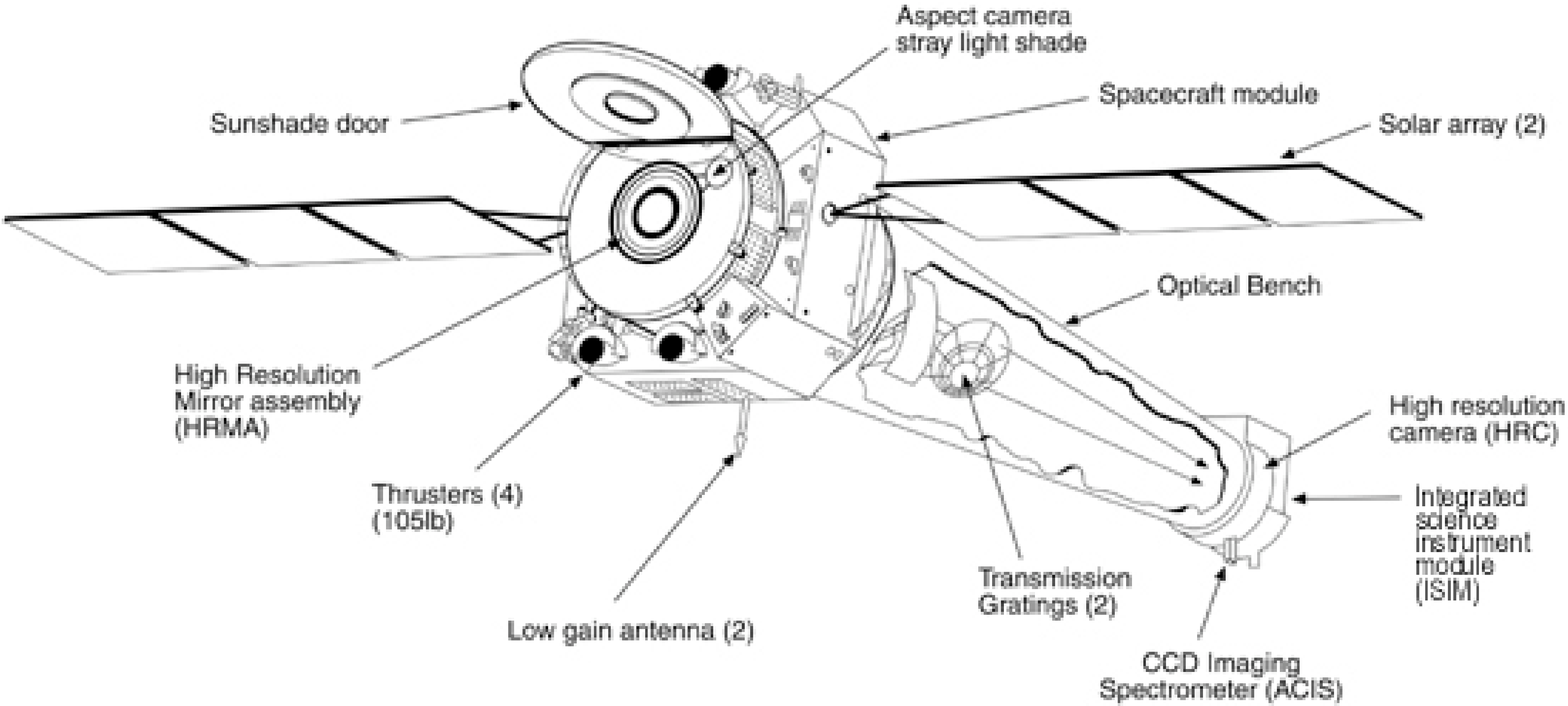
With the launch of XMM/Newton, the Reflection Grating Spectrometer (RGS) was finally able to achieve the one true goal of all spectroscopists: a 52 ksec observation of Capella.



Audard *et al*. 2001

Grating Basics

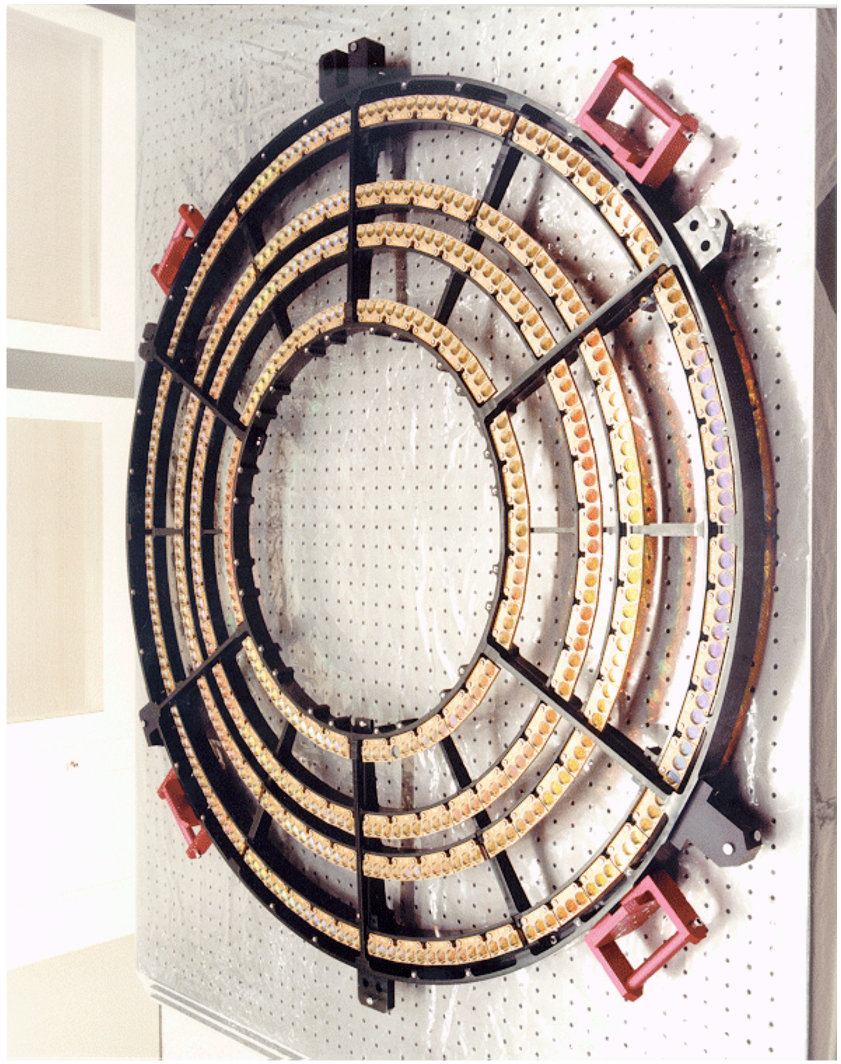
So, where do these gratings go? Here is a diagram of *Chandra*; notice the position of the removable gratings:



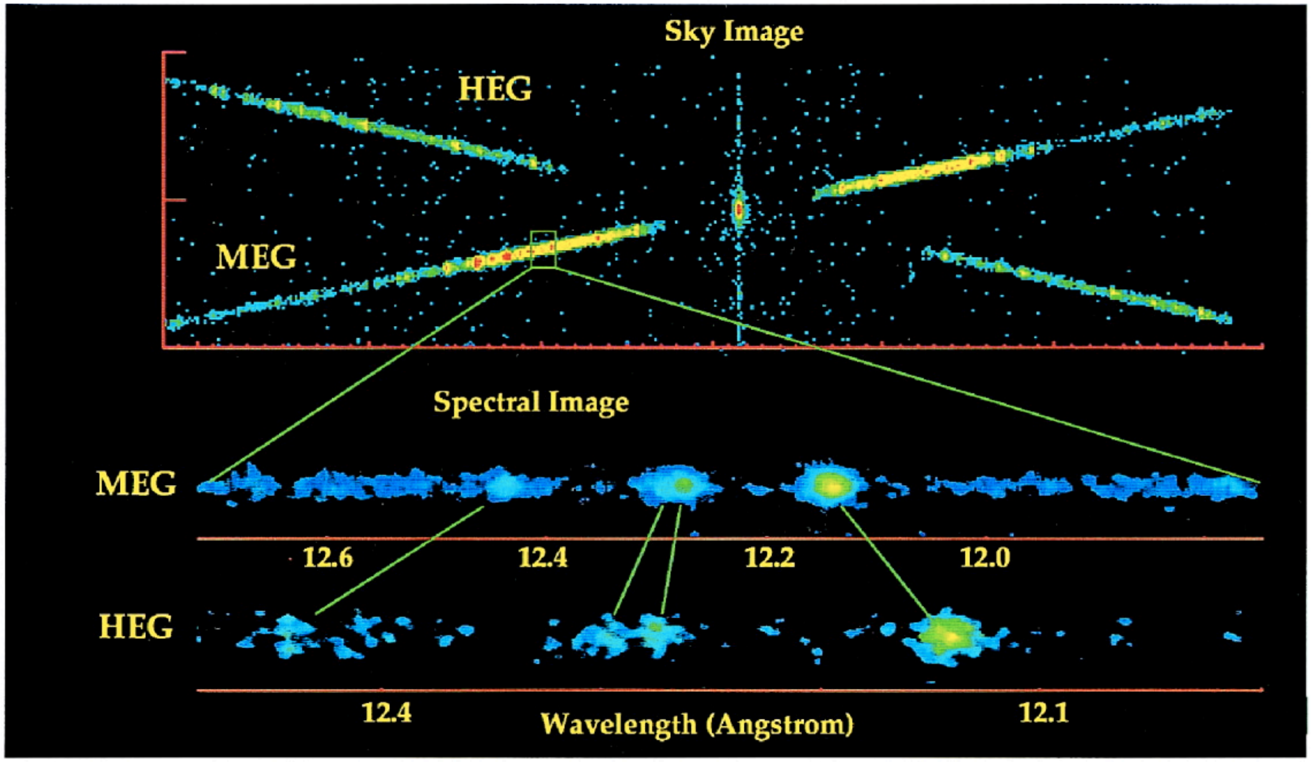
Grating Basics

Here is a the HETG, pre-installation. The many grating facets are all carefully positioned to catch the light from the 4 nested mirrors.

The LETG, pre-installation. Note the support structures, which will later show up as scattered light in deep LETG observations:



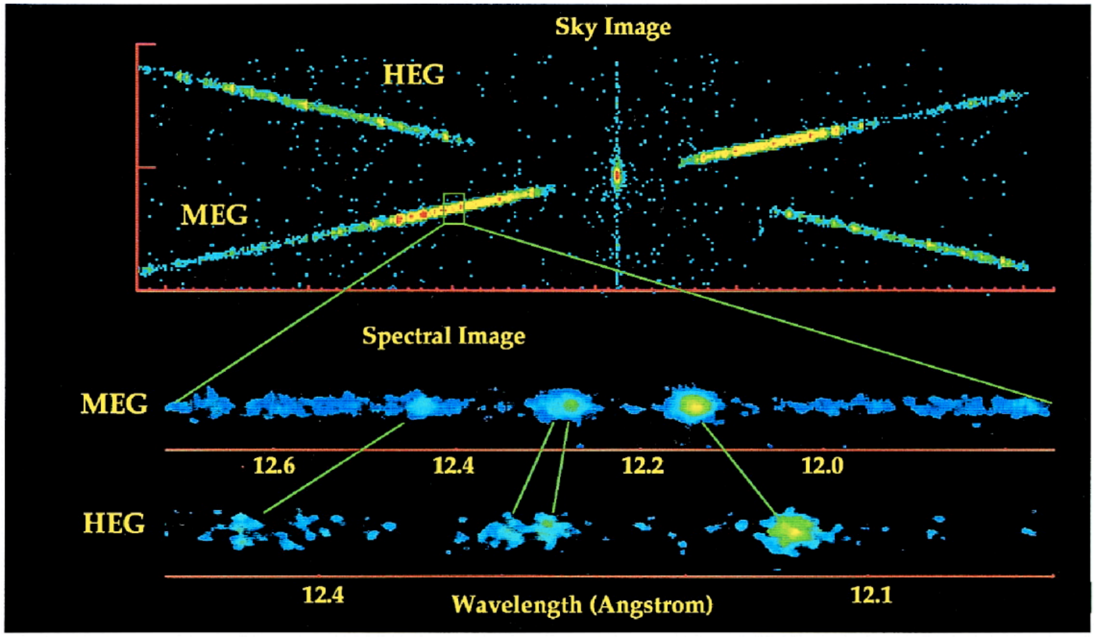
Grating Basics



Canizares et al. (2000)

The two arms of the HEG and MEG gratings can be clearly seen here. Notice the larger effective area of the MEG; the exploded region shows the effect of the HEG's higher resolution.

Grating Basics



Canizares et al. (2000)

X-ray gratings work identically to optical gratings; both follow the grating equation:

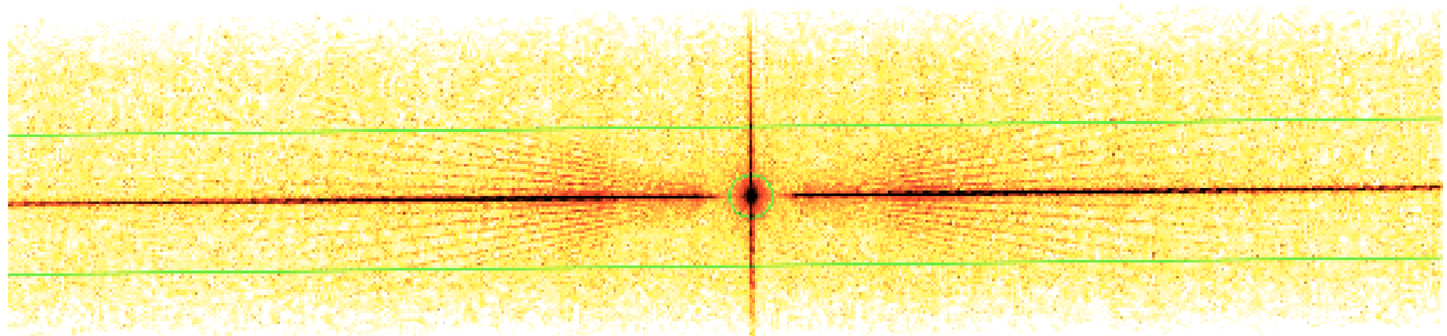
$$\sin \theta = m\lambda/p$$

where λ is the wavelength, θ is the dispersion angle (measured from the zero-order image), p is the spatial period of the grating itself, and m is the order (1st, 2nd, etc).

Grating Basics

$$\sin \theta = m\lambda/p$$

High-resolution (grating) spectra on Chandra cover a huge range of wavelengths: from 1.2-170Å, over two orders of magnitude. Note that although "wavelength" is the natural unit for grating data, many (older) X-ray astronomers use energy (keV) units anyway.

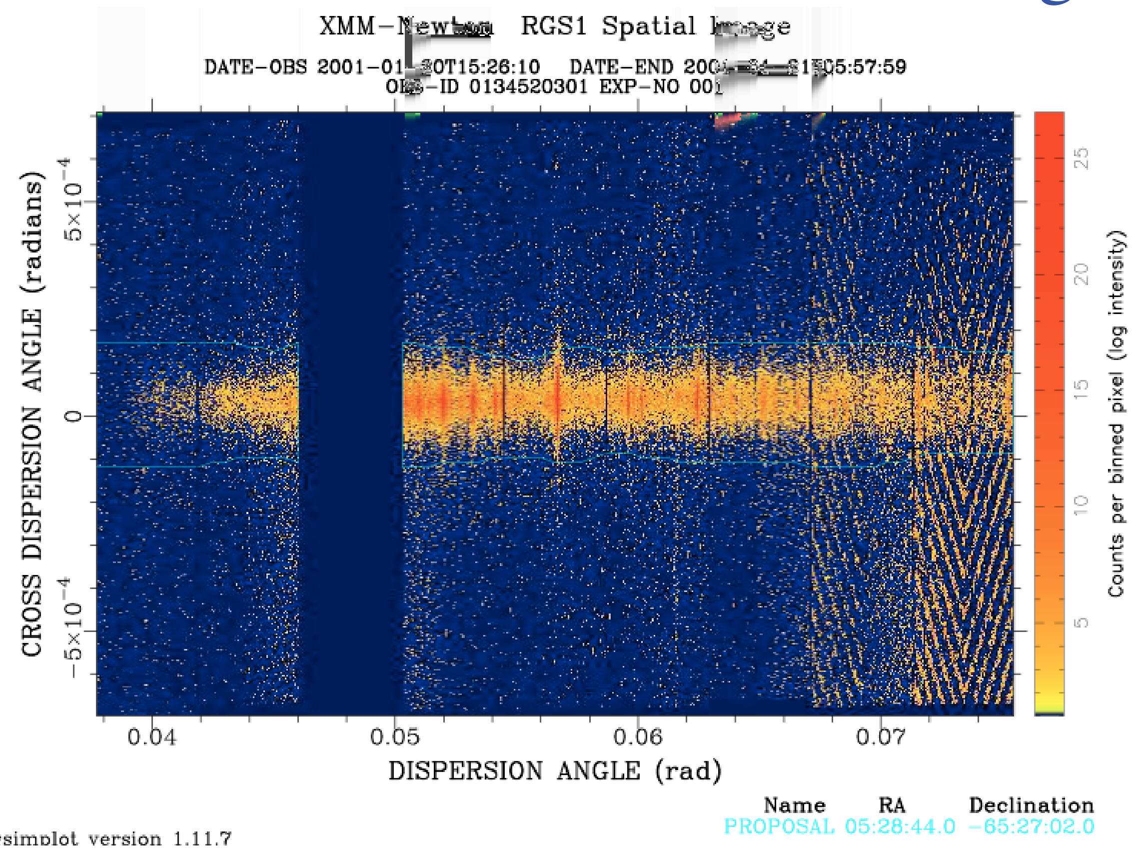


LETG/HRC-S observation of NGC6624

If ACIS is used, the CCD resolution can distinguish between the different orders; on the HRC, this must be modeled.

The spatial and spectral elements are tightly coupled. If the zero-order image is slightly displaced (*i.e.*, if the source is piled-up), the +/- order wavelengths will be offset from each other. If so, it calls for reprocessing.

The star AB Dor observed with the XMM RGS1



The light blue lines show the extraction region in the cross-dispersion direction. Notice the enhanced background on the rightmost chips; this can be (largely) eliminated by using the energy resolution of the CCDs. Also, one chip has failed; this also happened on RGS2, but fortunately at a different position.

Grating Basics

So, when you download grating data, what do you actually have?

ACIS/HETG	12 spectra; ±1,2,3 orders for both HEG and MEG
ACIS/LETG	6 spectra; ±1,2,3 orders for the LEG
HRC/LETG	2 spectra; $\pm\sum_n i$ orders
HRC/HETG	Not recommended
XMM/RGS	4 spectra; +1,2 from each of two RGSs.

For Chandra data, these are stored in one file with multiple spectra, a PHA Type II file; for XMM data, each spectrum is in a different PHA Type I file.

Grating Basics

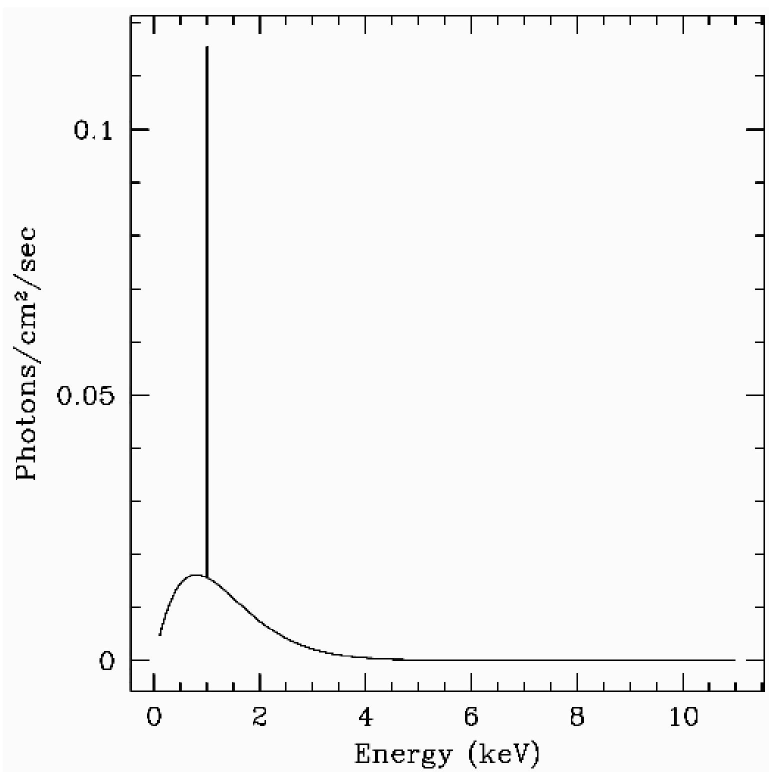
The characteristics of the different gratings in their prime arrangement:

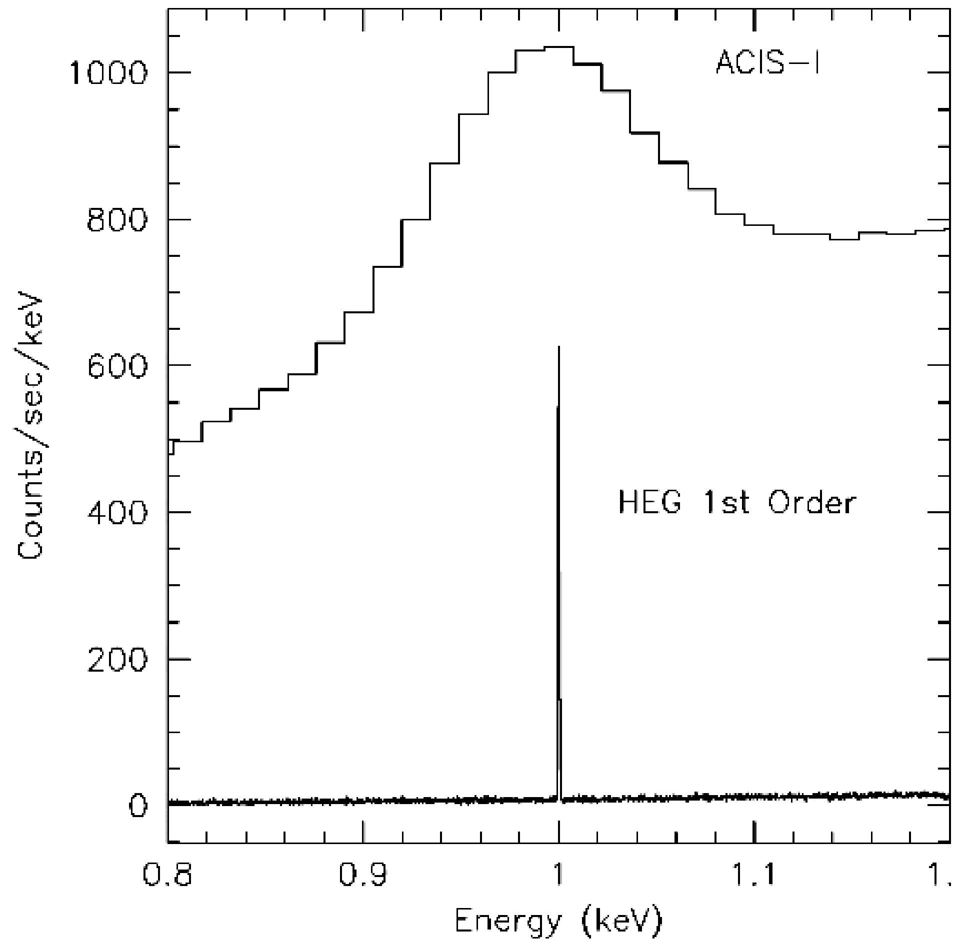
Grating	□□ (Å)	Resolution @ 1keV	Eff. Area @ 1keV (cm^{-2})
HEG 1st	0.012	1000	10
MEG 1st	0.023	540	34
LEG 1st	0.05	250	25
RGS 1st	~0.06	200	150

Grating Basics

So, what can we do with grating data that we can't with CCDs?

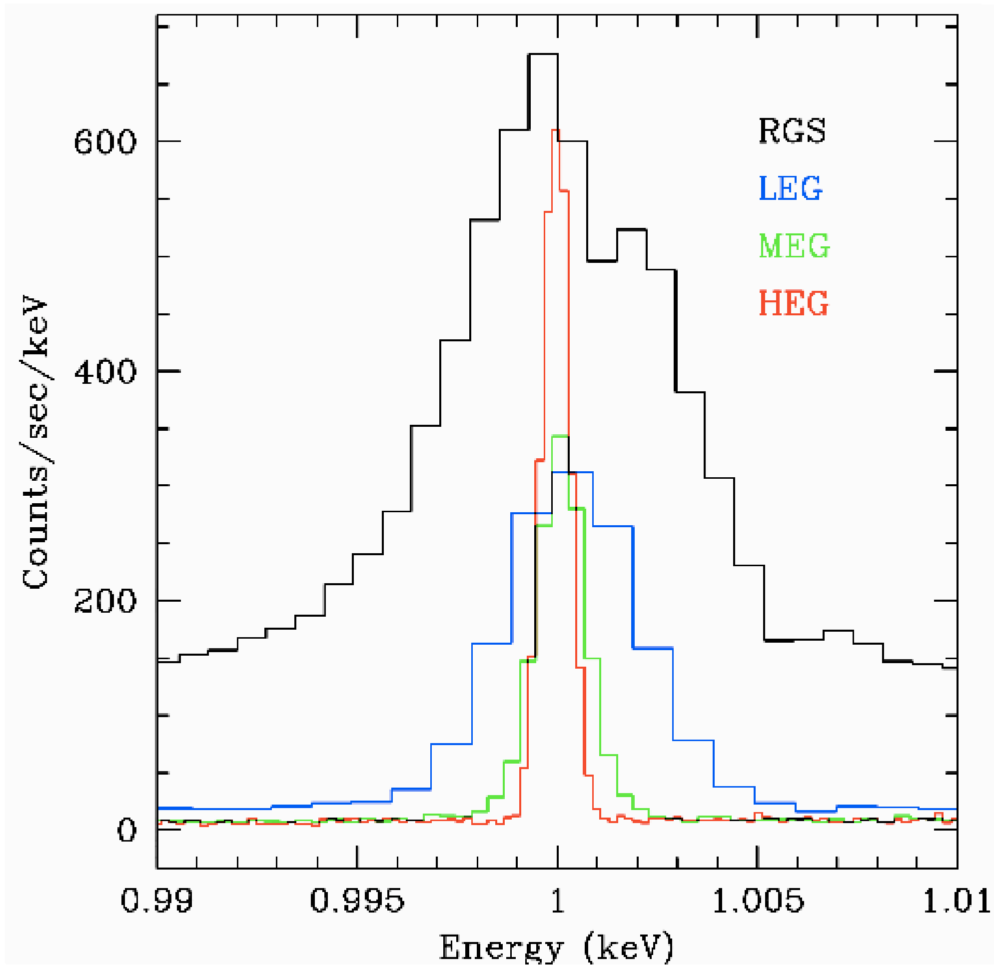
Consider a line at 1.0 keV (12.398Å), on top of a 0.5 keV blackbody





Grating Basics

Now consider the same spectrum observed by each of the four gratings:



If this data were fit assuming a pure Gaussian response, the scattering wings of the RGS would mean we'd measure only 1/2 the true power!

Processing

This talk really isn't about actual data processing; if you find yourself needing to reduce *Chandra* and/or *XMM/Newton* grating data, I recommend:

RGS	http://heasarc.gsfc.nasa.gov/docs/xmm/abc/node8.html
HETG/ACIS	http://cxc.harvard.edu/ciao/threads/spectra_hetgacis.html
LETG/ACIS	http://cxc.harvard.edu/ciao/threads/spectra_letgacis.html
LETG/HRC	http://cxc.harvard.edu/ciao/threads/spectra_letghrc.html

The end product will be either multiple Type I or a Type II PHA file(s); basically, a histogram of counts as a function of wavelength, along with the instrumental response.

Processing

The XMM/Newton RGS is a reflection grating, while the Chandra LETG and HETG are transmission gratings. However, the basic processing steps are similar:

1. Identify the dispersed source(s). In some cases, multiple sources may be present; both CIAO and SAS software can identify and reduce more than one source, but the user must select which source to extract.
2. Calculate the dispersion distance for each event, and (if available) resolve the order by comparing the dispersion wavelength to the measured CCD energy.
3. Extract the spectrum into a PHA file, suitable for use in Sherpa or XSPEC.
4. Create the detector response for the source. This depends on the position of the source on the detector, the aspect solution, and the operating mode of the telescope. The variations are not generally large, so using another observation's response is OK for quick work.

SAS does steps 1-3 with one command, **rgsproc**. *Chandra* breaks steps 1-3 into subprograms: **tg_create_mask**, **tg_resolve_events**, and **tgextract**.

Know your Data: RGS event files

unix% dmlist rgs_evt2.fits cols

Columns for Table Block EVENTS

ColNo	Name	Unit	Type	Range	Null	
1	TIME		Real8	-Inf:+Inf	-	frame timestamp
2	FLAG		Int4	-	-	event attribute flags
3	BETA		Real4	-Inf:+Inf	-	uncorrected dispersion angle
4	XDSP		Real4	-Inf:+Inf	-	uncorrected cross-dispersion ang
5	CHIPX		PIXELS	Int2	-	chip x coordinate
6	CHIPY		PIXELS	Int2	-	chip y coordinate
7	PHA		Int2	-	-	total telemetered energy
8	SHAPE		Byte	-	-	event shape identifier
9	GRADE		Byte		-	total number of pixels
10	PI		Int2	-	-	total corrected energy
11	CCDNR		Byte			CCD number (1/14)
12	BETA_CORR	rad	Real4	-Inf:+Inf	-	The name of this column
13	XDSP_CORR	rad	Real4	-Inf:+Inf		The name of this column
14	M_LAMBDA	Angstrom	Real4	-Inf:+Inf	-	The name of this column
15	BETA_CHANNEL		Int2	1:3400	-32768	The name of this column
16	XDSP_CHANNEL		Int2	1:170	-32768	The name of this column

Know your Data: HETG/ACIS event files

unix% dmlist acis_evt2.fits cols

Columns for Table Block EVENTS

#	Name	Unit	Type	Range	
1	time	s	Real8	5.66e7: 5.664e7	time tag of data record
2	expno		Int4	0:2147483647	
3	rd(tg_r,tg_d)	deg	Real4	-2.0:2.0	Grating angular coords
4	chip(chipx,chipy)	pixel	Int2	1:1024	Chip coords
5	tdet(tdetx,tdety)	pixel	Int2	1:8192	Tdet coords
6	det(detx,dety)	pixel	Real4	0.50:8192.50	Det coords
7	sky(x,y)	pixel	Real4	0.50:8192.50	Sky coords
8	ccd_id		Int2	0:9	
9	pha		Int4	0:36855	
10	pi		Int2	1:1024	
11	energy		Real4	0:1000000.0	
12	grade		Int2	0:7	
13	fltgrade		Int2	0:255	
14	node_id		Int2	0:3	
15	tg_m		Int2	-62:62	Diffraction order (m)
16	tg_lam	angstrom	Real4	0:400.0	wavelength (lambda)
17	tg_mlam	angstrom	Real4	-400.0:400.0	Order times wavelength (m * lambda)
18	tg_srcid		Int2	0:32767	source ID, index from detect table
19	tg_part		Int2	0:99	HEG, MEG, LEG, HESF regions
20	tg_smap		Int2	0:32767	source map; flags for up to 10 sources
21	status[4]		Bit(4)		event status bits

Know your Data: LETG/HRC event files

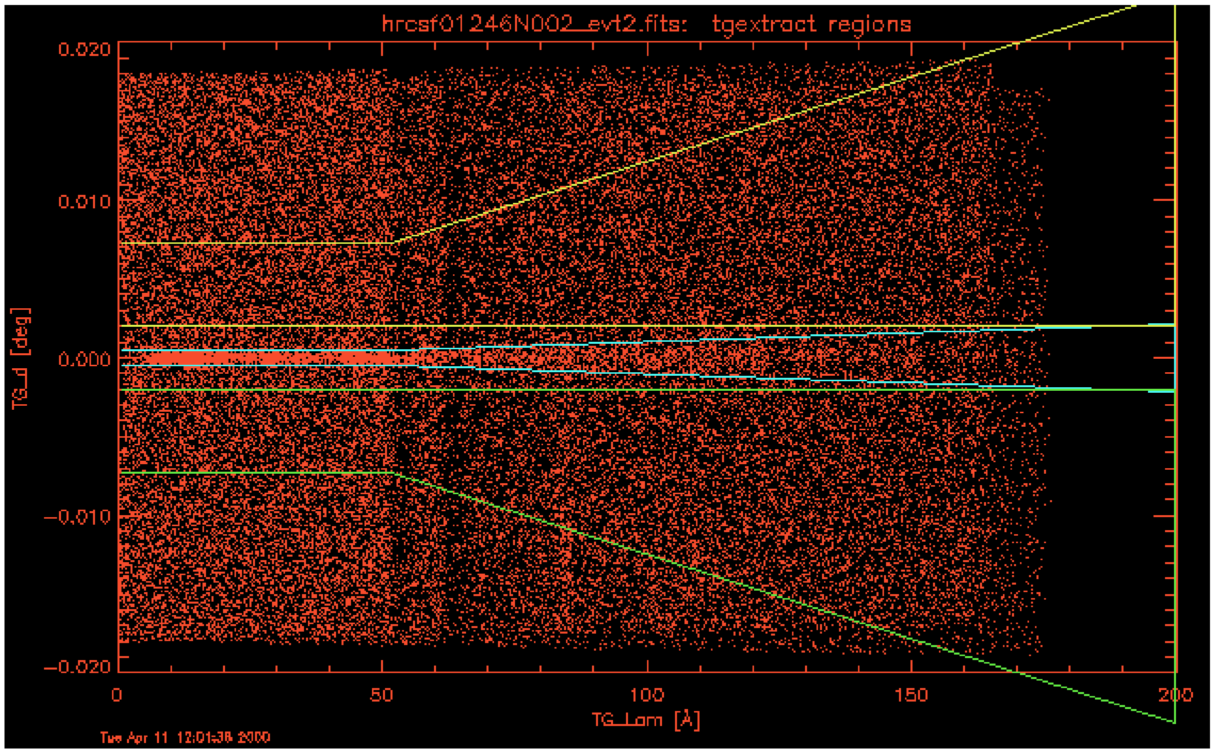
unix% dmlist hrc_evt2.fits cols

Columns for Table Block EVENTS

#	Name	Unit	Type	Range	Description
1	time	s	Real8	6.9e7:7.0e7	time tag of data record
2	rd(tg_r,tg_d)	deg	Real4	-2.0: 2.0	Grating angular coords
3	chip(chipx,chipy)	pixel	Int2	1:4096	Chip coords
4	tdet(tdetx,tdety)	pixel	Int4	1:49368	Tdet coords
5	det(detx,dety)	pixel	Real4	0.50:65536.50	Det coords
6	sky(x,y)	pixel	Real4	0.50:65536.50	Sky coords
7	chip_id		Int2	1:3	
8	pha		Int2	0:255	
9	pi		Int2	0:255	
10	tg_m		Int2	-62:62	Diffraction order (m)
11	tg_lam	angstrom	Real4	0: 400.0	wavelength (lambda)
12	tg_mlam	angstrom	Real4	-400.0:400.0	Order times wavelength (m * lambda)
13	tg_srcid		Int2	0:32767	source ID, index from detect table
14	tg_part		Int2	0:99	HEG, MEG, LEG, HESF regions
15	tg_smap		Int2	0:32767	source map; flags for up to 10 sources
16	status[4]		Bit(4)		event status bits

Processing

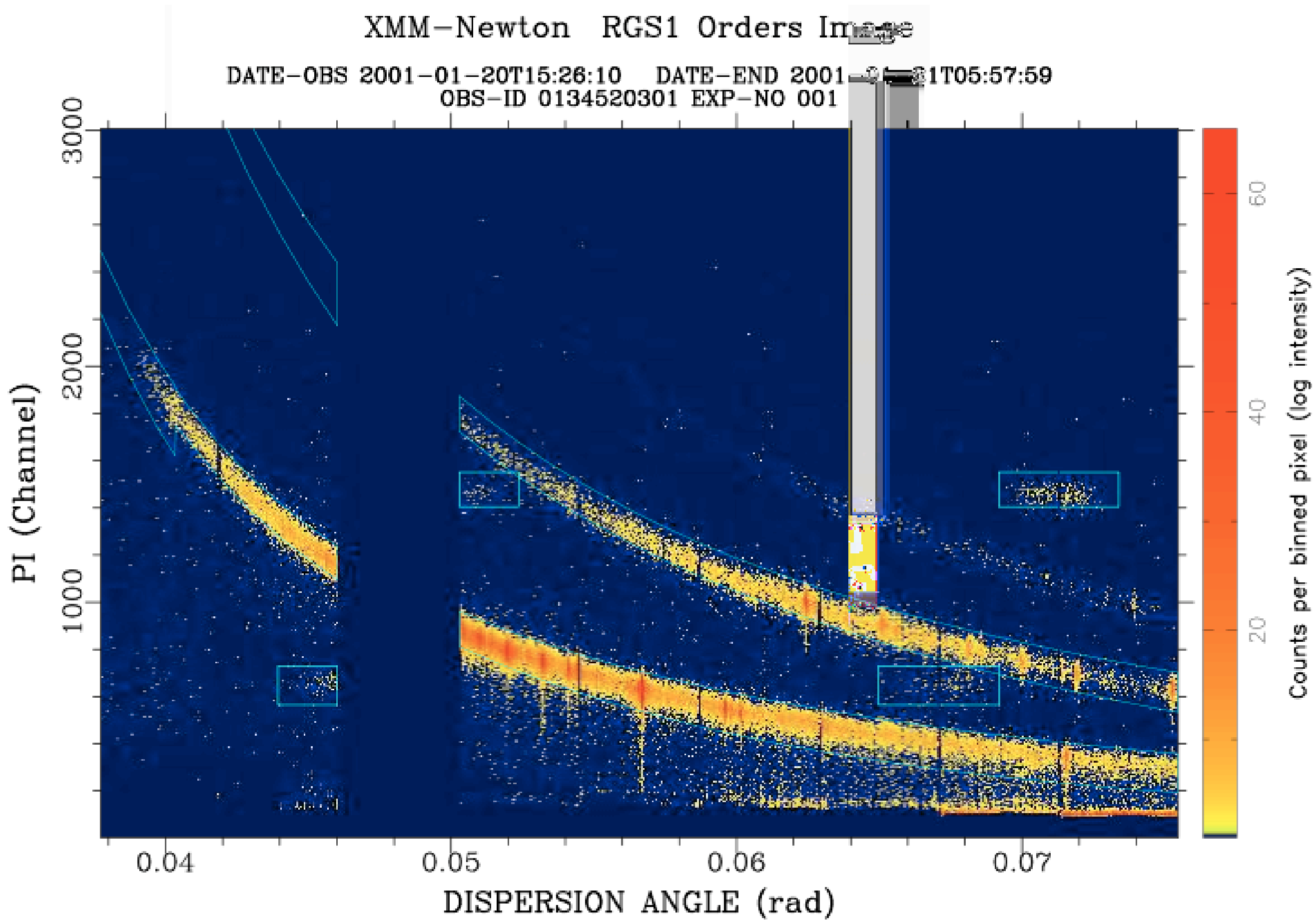
For bright sources on ACIS-S, the background is likely negligible. However, on the HRC-S or with the RGS it isn't:



Source/Background regions for the HRC/LETG

Proper background subtraction is still a topic of some debate!

Processing



XMM RGS1 spectra of the star AB Dor

Using a detector with even moderate energy resolution can substantially reduce the background, because one can cross-correlate the wavelength measured from the dispersed position with the energy measured in the CCD using the relation:

$$E_{keV} = 12.398 / \lambda_{Å}$$

What if you want both high-resolution spectra AND timing?

1) You’d better have a bright source

2) With *Chandra*, the ACIS detectors can be run in continuous clocking mode while either of the gratings are in place. The time resolution is about 3 ms.

3) With XMM/Newton, the RGS detectors can be run in CC mode, but as of this writing (May 2003) this mode is not available to users for technical reasons.

4) The HRC has good time resolution, but due to an electronics problem, the time tags for each event suffer from an off-by-one problem and actually refer to the previous event. It is possible to run the HRC in a “timing” mode where this is mitigated, but not with the full grating array.

Processing

Unfortunately, not every X-ray source is as bright as Capella or NGC6624. What can you do to enhance the S/N? In this case, you have 4 choices:

1) **Co-add plus/minus orders of the same grating** ⇨ *Can broaden lines if zero-order is offset.*
2) **Co-adding different gratings, such as HEG and MEG or RGS1 and RGS2** ⇨ *Complicates line shape function.*
3) **Co-add separate observations** ⇨ *Instrumental background can vary, plus the same issues of zero-order offsets.*
4) **Co-add separate observations and instruments** ⇨ *All of the above*

Grating Analysis

Load data

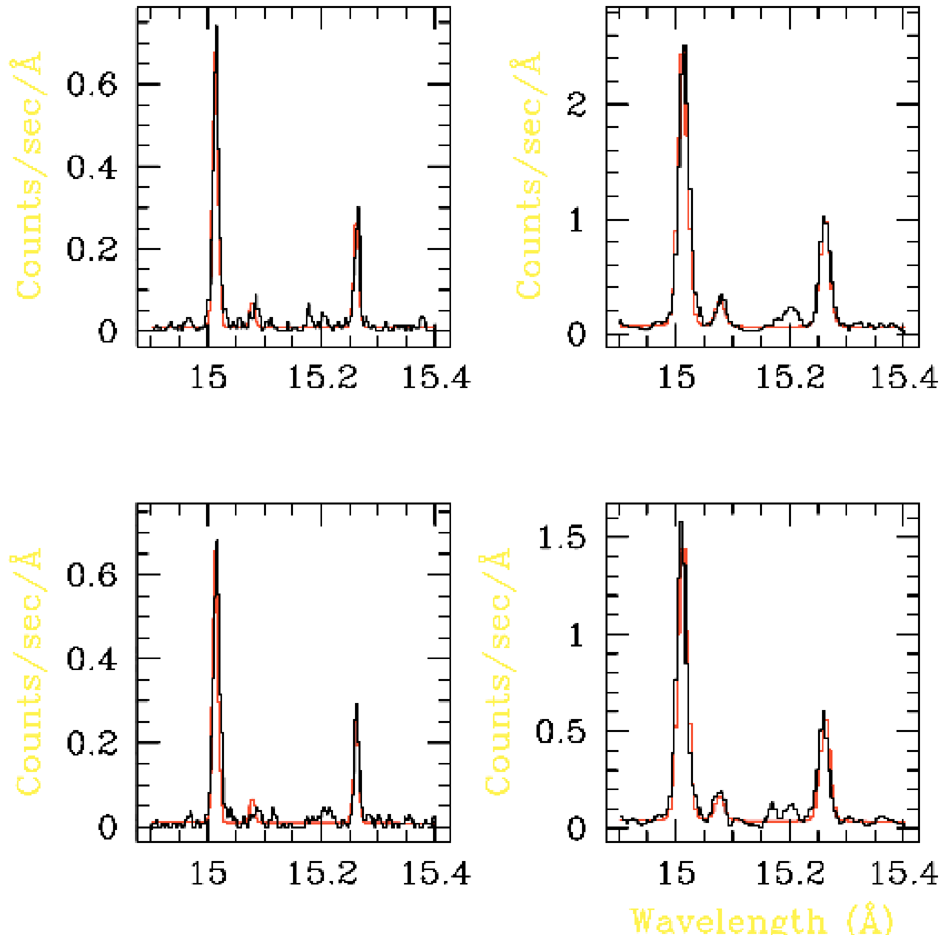
Define instrument response

Define source

Display results

```
unix% sherpa
sherpa> data acis_pha2.fits
sherpa> paramprompt off
sherpa> rsp[hm1]
sherpa> rsp[hp1]
sherpa> rsp[mm1]
sherpa> rsp[mp1]
sherpa> hm1.rmf = acisheg1D1999-07-22rmfN0004.fits
sherpa> hm1.arf = acisf01318HEG_-1_garf.fits
sherpa> hp1.rmf = acisheg1D1999-07-22rmfN0004.fits
sherpa> hp1.arf = acisf01318HEG_1_garf.fits
sherpa> mm1.rmf = acismeg1D1999-07-22rmfN0004.fits
sherpa> mm1.arf = acisf01318MEG_-1_garf.fits
sherpa> mp1.rmf = acismeg1D1999-07-22rmfN0004.fits
sherpa> mp1.arf = acisf01318MEG_1_garf.fits
sherpa> instrument 3 = hm1
sherpa> instrument 4 = hp1
sherpa> instrument 9 = mm1
sherpa> instrument 10= mp1
sherpa> ignore allsets all
sherpa> notice allsets wave 14.9:15.4
sherpa> source 3,4,9,10 = poly[b1] + delta1d[l1] + delta1d[l2] + delta1d[l3]
sherpa> l1.pos = 15.014
sherpa> l2.pos = 15.079
sherpa> l3.pos = 15.2610
sherpa> freeze l1.pos
sherpa> freeze l2.pos
sherpa> freeze l3.pos
sherpa> fit
sherpa> lp 4 fit 3 fit 4 fit 9 fit 10
sherpa> import(``guide")
sherpa> mdl2latex
\begin{tabular}{lllllll}
ModelName & Line Model & Position & Flux & Flux Error & Fit Data & Label \\
 &  & Angstrom & ph/cm$^2$/s & ph/cm$^2$/s &  \\
l1 & delta1d & 15.014 & 0.00308923 & 6.7101e-05 & 3,4,9,10 &  \\
l2 & delta1d & 15.079 & 0.000270431 & 2.81612e-05 & 3,4,9,10 &  \\
l3 & delta1d & 15.261 & 0.00125857 & 4.79625e-05 & 3,4,9,10 &  \\
```

Grating Analysis



Results from Sherpa fits; notice the low background in the HEG data, and the higher resolution.

ModelName	Line Model	Position Angstrom	Flux ph/cm^2/s	Flux Error ph/cm^2/s	Fit Data	Label
l1	delta1d	15.014	0.00308923	6.7101e-05	3,4,9,10	
l2	delta1d	15.079	0.000270431	2.81612e-05	3,4,9,10	
l3	delta1d	15.261	0.00125857	4.79625e-05	3,4,9,10	

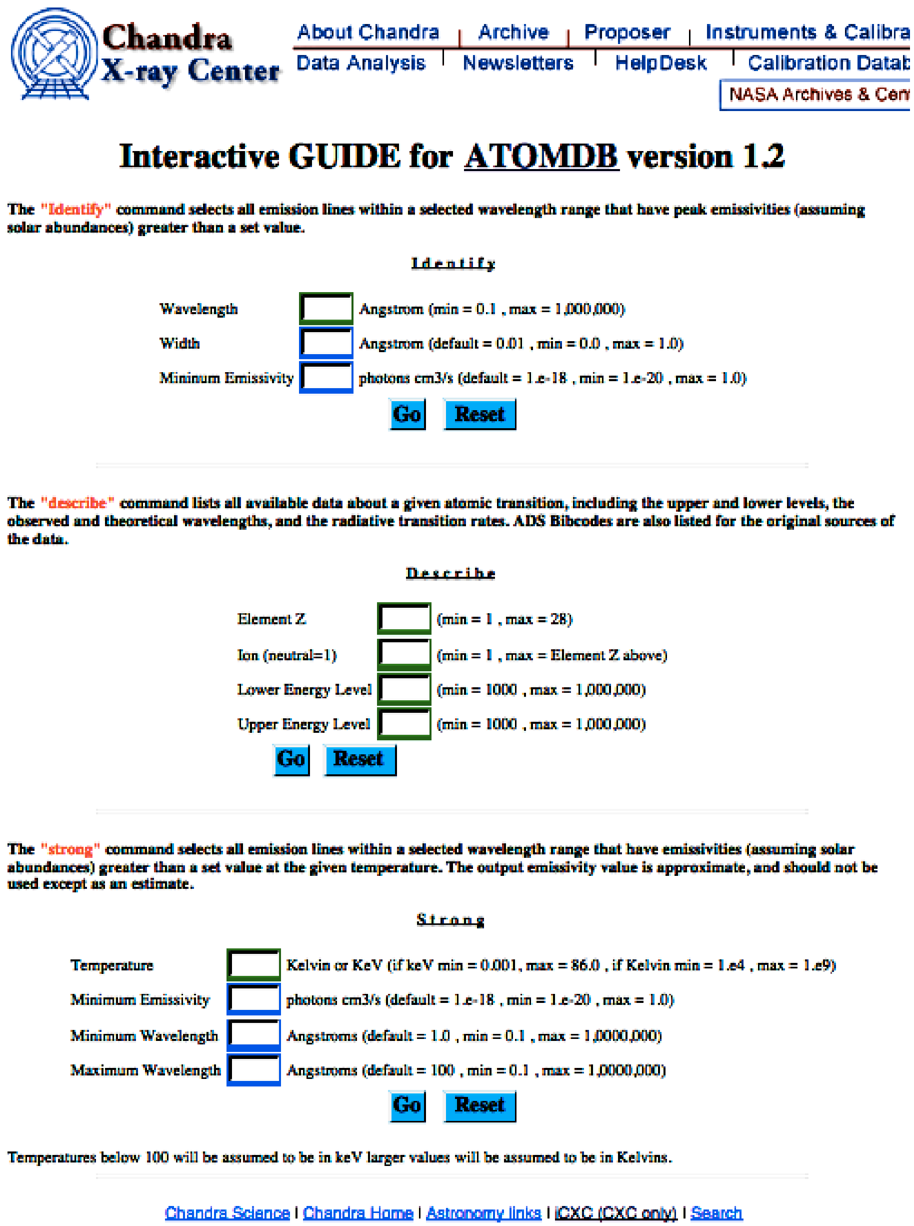
Guide

GUIDE is a collection of scripts which access the atomic database ATOMDB. GUIDE provides a number of informational functions:

identify	Print finding chart of wavelengths
strong	List strong lines at a given temperature
describe	Describe atomic parameters of a line
mdl2latex	Convert fit parameters into a latex table
ionbal	Output ionization balance fractions for a given ion

GUIDE works in Sherpa or Chips; initialize it with **import(“guide”)**

WebGUIDE



Chandra X-ray Center

About Chandra | Archive | Proposer | Instruments & Calibra
Data Analysis | Newsletters | HelpDesk | Calibration Datab
NASA Archives & Cen

Interactive GUIDE for ATOMDB version 1.2

The "Identify" command selects all emission lines within a selected wavelength range that have peak emissivities (assuming solar abundances) greater than a set value.

Identify

Wavelength	Angstrom (min = 0.1 , max = 1,000,000)
Width	Angstrom (default = 0.01 , min = 0.0 , max = 1.0)
Minimum Emissivity	photons cm3/s (default = 1.e-18 , min = 1.e-20 , max = 1.0)

Go Reset

The "describe" command lists all available data about a given atomic transition, including the upper and lower levels, the observed and theoretical wavelengths, and the radiative transition rates. ADS Bibcodes are also listed for the original sources of the data.

Describe

Element Z	(min = 1 , max = 28)
Ion (neutral=1)	(min = 1 , max = Element Z above)
Lower Energy Level	(min = 1000 , max = 1,000,000)
Upper Energy Level	(min = 1000 , max = 1,000,000)

Go Reset

The "strong" command selects all emission lines within a selected wavelength range that have emissivities (assuming solar abundances) greater than a set value at the given temperature. The output emissivity value is approximate, and should not be used except as an estimate.

Strong

Temperature	Kelvin or KeV (if keV min = 0.001, max = 86.0 , if Kelvin min = 1.e4 , max = 1.e9)
Minimum Emissivity	photons cm3/s (default = 1.e-18 , min = 1.e-20 , max = 1.0)
Minimum Wavelength	Angstroms (default = 1.0 , min = 0.1 , max = 1,0000,000)
Maximum Wavelength	Angstroms (default = 100 , min = 0.1 , max = 1,0000,000)

Go Reset

Temperatures below 100 will be assumed to be in keV larger values will be assumed to be in Kelvins.

Chandra Science | Chandra Home | Astronomy links | ICXC (CXC only) | Search

Emission lines within 0.1 Angstroms of 13.5 Angstroms (Emissivity > 5.e-18)

Lambda Angstrom	Ion	Upper Level	Lower Level	Emissivity ph cm3/s	@	kT keV	Relative Intensity	For More Info
13.4070	Fe XVIII	69	1	1.12e-17	@	0.685	0.028	describe(26,18,69,1)
13.4091	Fe XX	107	6	1.92e-17	@	0.862	0.047	describe(26,20,107,6)
13.4181	Fe XX	116	7	1.20e-17	@	0.862	0.030	describe(26,20,116,7)
13.4230	Fe XIX	76	1	3.32e-17	@	0.685	0.082	describe(26,19,76,1)
13.4308	Fe XXI	82	13	1.61e-17	@	0.862	0.040	describe(26,21,82,13)
13.4440	Fe XX	116	8	8.75e-18	@	0.862	0.022	describe(26,20,116,8)
13.4440	Fe XXII	17	8	2.24e-17	@	1.085	0.055	describe(26,22,17,8)
13.4473	Ne IX	7	1	4.06e-16	@	0.343	1.000	describe(10,9,7,1)
13.4510	Fe XVIII	67	1	1.23e-17	@	0.685	0.030	describe(26,18,67,1)
13.4620	Fe XIX	74	1	7.53e-17	@	0.685	0.185	describe(26,19,74,1)
13.4700	Ne IX	10095	8	6.98e-18	@	0.273	0.017	describe(10,9,10095,8)
13.4910	Ne IX	10089	6	5.94e-18	@	0.273	0.015	describe(10,9,10089,6)
13.4970	Fe XIX	71	1	1.32e-16	@	0.685	0.325	describe(26,19,71,1)
13.5070	Fe XXI	42	7	1.16e-16	@	0.862	0.285	describe(26,21,42,7)
13.5180	Fe XIX	68	1	2.91e-16	@	0.685	0.717	describe(26,19,68,1)
13.5312	Fe XIX	79	3	9.30e-18	@	0.685	0.023	describe(26,19,79,3)
13.5347	Fe XXII	18	9	6.76e-18	@	1.085	0.017	describe(26,22,18,9)
13.5350	Fe XX	107	7	2.91e-17	@	0.862	0.072	describe(26,20,107,7)
13.5350	Fe XX	109	7	1.66e-17	@	0.862	0.041	describe(26,20,109,7)
13.5510	Fe XIX	65	1	1.90e-17	@	0.685	0.047	describe(26,19,65,1)
13.5531	Ne IX	5	1	6.37e-17	@	0.343	0.157	describe(10,9,5,1)
13.5540	Fe XIX	67	1	6.60e-18	@	0.685	0.016	describe(26,19,67,1)
13.5583	Fe XX	110	8	1.28e-17	@	0.862	0.031	describe(26,20,110,8)
13.5654	Fe XX	109	8	1.25e-17	@	0.862	0.031	describe(26,20,109,8)
13.5740	Fe XXI	39	7	1.97e-17	@	0.862	0.048	describe(26,21,39,7)

WebGUIDE

Level Transition for Ion Ne IX, from 1 to 7

Ion Ne IX, energy level 1 ---

electron configuration	:	1s^2~^1S_{0}
energy above ground (eV)	:	0.000000
Quantum state	:	n=1, l=N/A, s=0, degeneracy=1
Energy level data source	:	1983ADNDT..29..467S
Photoionization data source	:	1986ADNDT..34..415C

Ion Ne IX, energy level 7 ---

electron configuration	:	1s2p~^1P_{1}
energy above ground (eV)	:	922.609985
Quantum state	:	n=2, l=1, s=0, degeneracy=3
Energy level data source	:	1983ADNDT..29..467S
Photoionization data source	:	1986ADNDT..34..415C

Ion Ne IX, 1 - 7 interactions ---

Electron collision rate from 1 -> 7	:	nonzero.
Reference bibcode	:	1983ADNDT..29..467S
Wavelength (lab/observed) (Angstrom)	:	13.447307 +/- 0.004000
Wavelength (theory) (Angstrom)	:	13.470000
Transition rate/Einstein A (s^-1)	:	8.866670e+12
Wavelength (lab/observed) reference	:	1988CaJPh..66..586D
Wavelength (theory) reference	:	1983ADNDT..29..467S
Transition rate reference	:	1987JPhB...20.6457F

Grating Analysis

When faced with the task of understanding a high-resolution spectrum, especially a line-dominated one, it is likely that simple equilibrium models will not work adequately, despite possibly giving low reduced χ^2 values--usually because the counts/bin is low and so the errors are overestimated, not because the fits are good.

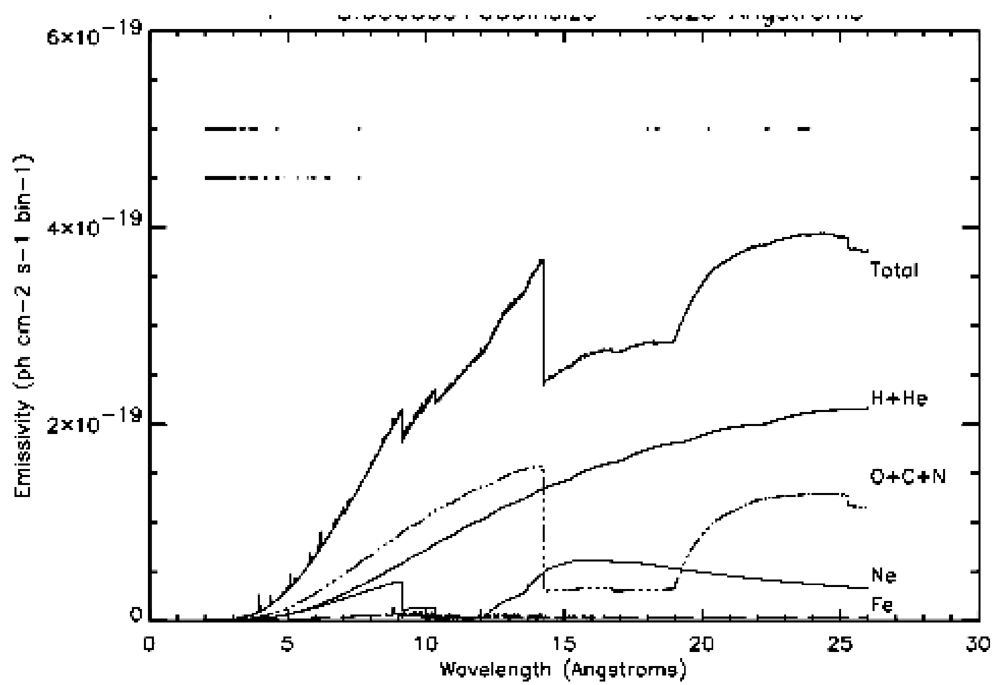
In this case, some new strategies are needed. Here are some suggestions for starting points.

First: Determine if your plasma is dominated by photoionization or collisional ionization. For example, the initial analysis of ASCA\ data of Cygnus X-3 used a collisional model, even though the emission is due to photoionization (see Liedahl & Paerels 1996)

Make a list of all processes that could be affecting line emission. For example, in helium-like ions, the three dominant lines are the resonance, the forbidden, and the intercombination lines. These can be excited by direct excitation, radiative recombination, dielectronic recombination of hydrogen-like ions, innershell ionization of lithium-like ions, cascades from higher levels, or by photoexcitation or photoionization. Once created, the lines can be absorbed or scattered by like ions or by different ions. In many cases, simple physical arguments can be used to limit or exclude various processes, reducing the parameter space that must be searched.

Grating Analysis

Second: Attempt to determine the true continuum level with confidence. The continuum in a hot plasma is not necessarily dominated by bremsstrahlung:



Weak emission lines will also blend in to make the continuum seem larger, which will lead to a systematic underestimate of line fluxes, and therefore elemental and ionic abundances. After you have found an acceptable spectral model, search for regions in the model with no or few lines, and compare the model to the data in this region. If the model continuum overestimates the continuum here, it is likely it overestimates it everywhere due to unresolved line emission

AstroAtom

Institute for Theoretical Atomic and Molecular Physics - Chandra X-Ray Center

Hi randallksmith

Question	Announcement	New Paper

Electron impact excitation of helium-like oxygen up to n = 4 levels including radiation damping

Authors: Franck Delahaye , Anil K Pradhan
Reference: J. Phys. B: At. Mol. Opt. Phys. 35 (28 August 2002) 3377-3390
Ref.URL : http:// stacks.iop.org/0953-4075/35/3377
Keywords: Ion: Helium-like
Posted by: Randall Smith on 2002-10-15

The authors present relativistic R-matrix calculations of electron impact excitation of helium-like Oxygen, including levels up to n=4. They investigate the effective of radiation damping, and find that although resonances are noticebly damped as n->infinity, the overall effect on rate coefficients is very small. Results are compared to previous works and some significant differences are found.

Leave Comments

Excitation of Ar15+ and Fe23+ for diagnostic application to fusion and astrophysical plasmas

Authors: A D Whiteford , N R Badnell , C P Ballance , S D Loch
Reference: J. Phys. B: At. Mol. Opt. Phys. 35 (14 September 2002) 3729-3740
Ref.URL : http://stacks.iop.org/0953-4075/35/3729
Keywords: Ion: Lithium-like
Posted by: Randall Smith on 2002-10-15

M G O'Mullane, H P Summers: The authors present calculations of the Maxwellian-averaged collision strengths for singly- and doubly-excited lithium-like Argon and Iron, over a broad temperature range. The calculations were done using an R-matrix approach, including radiation and Auger damping. Results for n<=5 for singly-excited states and for n<=3 for doubly-excited states are included over a wide temperature range.

Leave Comments

Electron impact ionization of argon ions (q = 4-11)

Authors: H Zhang , S Cherkani-Hassani , C Bélenger , M Duponchelle
Reference: J. Phys. B: At. Mol. Opt. Phys. 35 (28 September 2002) 3829-3845
Ref.URL : http://stacks.iop.org/0953-4075/35/3829
Keywords: Ion: Nitrogen-like
Posted by: Randall Smith on 2002-10-15

M Khouilid, E M Oualim, P Defrance: The paper presents crossed electron-ion beam results for the electron impact ionization of argon ions, from Ar^4+ through Ar^11+. The results cover from threshold to ~6 keV,

Conclusions

- Reprocessing grating data is no longer absolutely required, but has gotten far easier and provides a sense of confidence about the data.
- Co-Adding and/or binning grating data should be avoided when possible. Remember that, statistically, nothing is gained by it, although it may be much faster to fit it and easier to see the results.
- A number of new facilities for atomic data analysis have been created for Sherpa and XSPEC However, remember to check the caveats on this data before trusting it totally! For the ATOMDB, they are at http://asc.harvard.edu/atomdb/doc/caveats.html
- Global fitting of generic equilibrium may be useful for guiding the analysis, but any project should begin with a physics-based approach, followed ideally by a line-based analysis and finally by checking regions which should well-understood (such as line-free areas or those dominated by a single line).