IXO Open Science Meeting
Stars and star-formation

Masahiro Tsujimoto

(JAXA/ISAS)

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Talk Plan

Scope:

My personal view for the IXO observatory science for stars and star formation.

Content:

1. Predicting future from the advances in the past.
2. A case study

1. Predicting Future (1/4)

Phase 0

- Num. of sources = 0
- Detection Experiment.

Phase II

- Num. of sources > a dozen.
- Established as a class.

Phase I

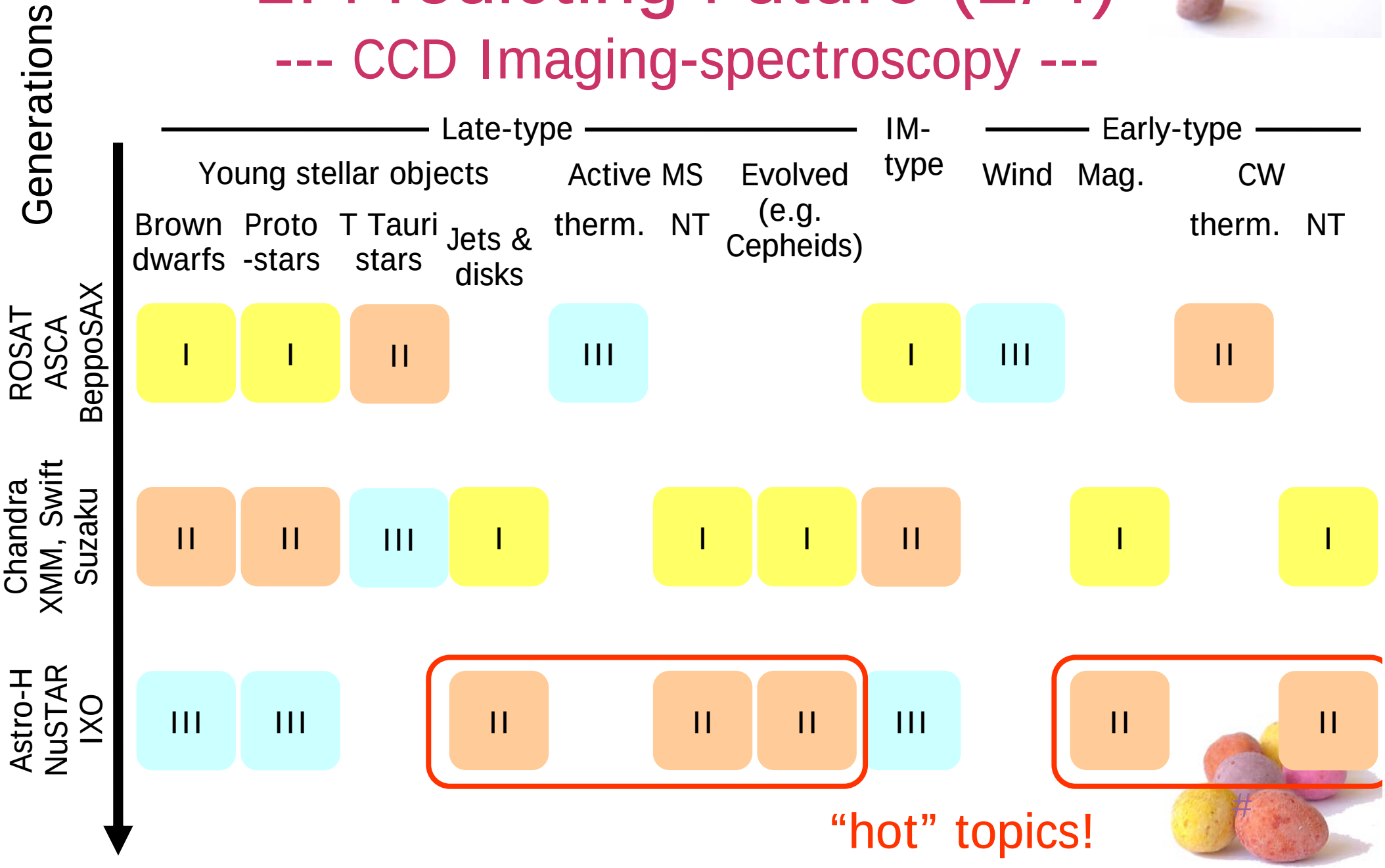
- Num. of sources > a few
- Many theory papers.
- Sub-classes proposed.

Phase III

- Num. of sources > a hundred.
- Used as a tool to address broader astrophysical issues.

1. Predicting Future (2/4)

--- CCD Imaging-spectroscopy ---



1. Predicting Future (3/4)

--- Grating/μCal spectroscopy ---

Generations

Late-type | IM-type | Early-type

Young stellar objects | Active MS | Evolved | Wind | Mag. | CW

Brown dwarfs | Proto -stars | T Tauri stars | Jets & disks | therm. | NT | (e.g. Cepheids) | therm. | NT

ROSAT ASCA BeppoSAX

Chandra XMM Suzaku

Astro-H NuSTAR IXO

I | I | II | I | I

I | II | II | III | II | II

"hot" topics!

1. Predicting Future (4/4)

--- “Hot” topics in the next generation ---

- Jets and disks in young stars.
- Evolved stars.
- Non-thermal emission from active stellar flares.
- Non-thermal emission in colliding-wind binaries (CWBs).
- High-resolution spectroscopy of protostars, T Tauri stars.
- Doppler tomography of X-ray active binaries.
- X-rays from early-type stars: magnetic vs colliding-winds.

2. A Case Study (1/3)

--- Protoplanetary disks in young stars ---

X-ray flares from proto-stars (=young Suns) illuminate their circum-stellar (proto-planetary) disks.

Crucial to unveil the initial condition of planet formation.

- X-rays are a major ionization source of disks (Glassgold+ 1997).
- It affects the disk chemistry and evolution (Nomura+ 2007).
- How close earth-like planets are formed to the primary star.

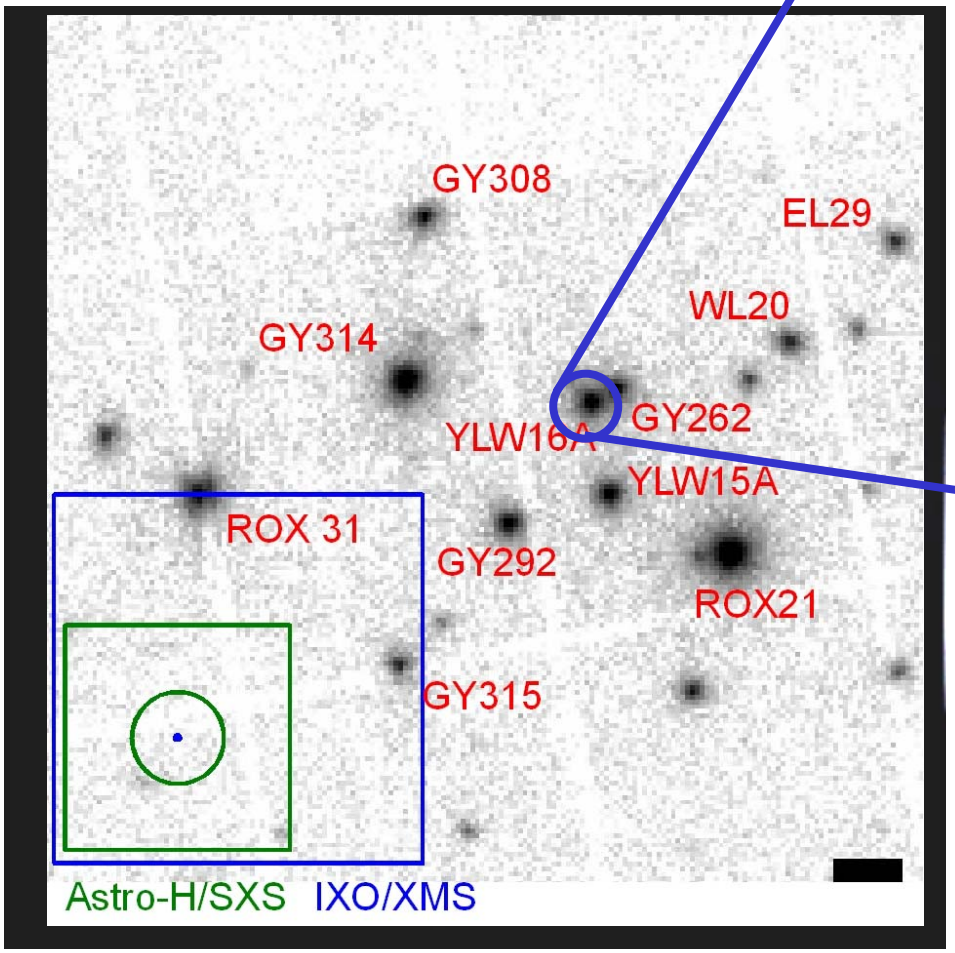
It is known (Imanishi+ 2001; Tsujimoto+ 2005) that

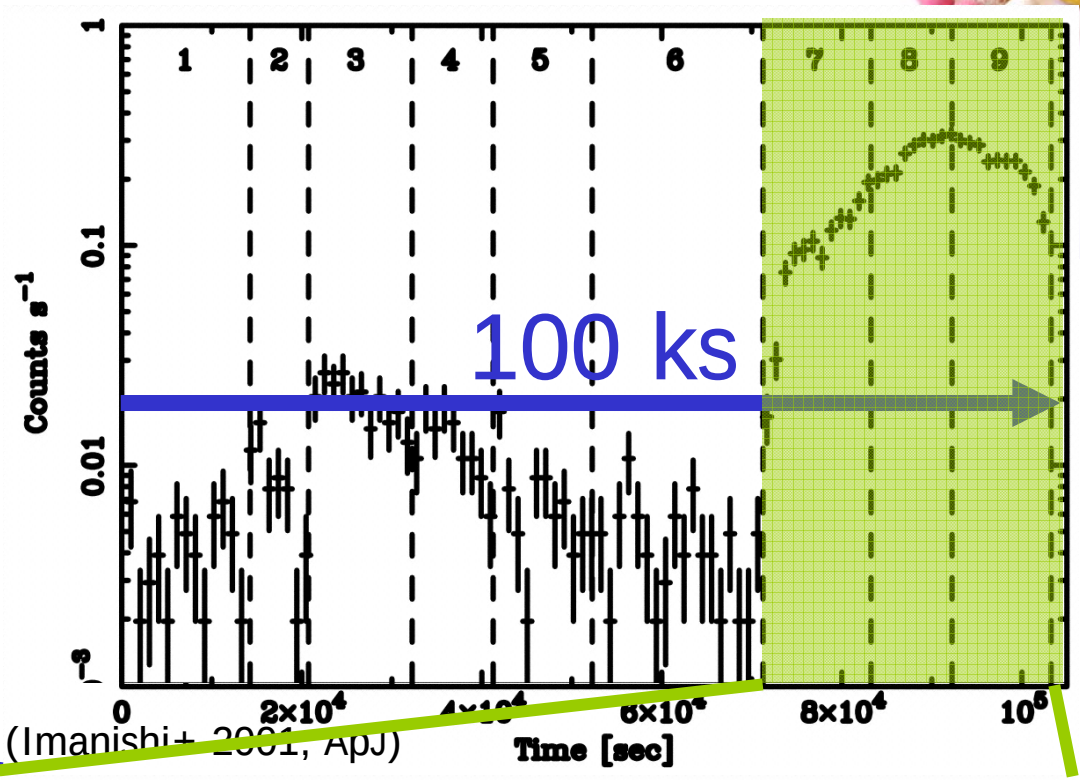
- Proto-stars commonly erupt flares occasionally (2-3/week).
- Fe I Ka fluorescence line emission at 6.4 keV is (1) the direct proof of photo-ionization, (2) a useful diagnosis to reveal the disk geometry & chemistry.

It is unknown (and next gen. missions will bring new big clues to)

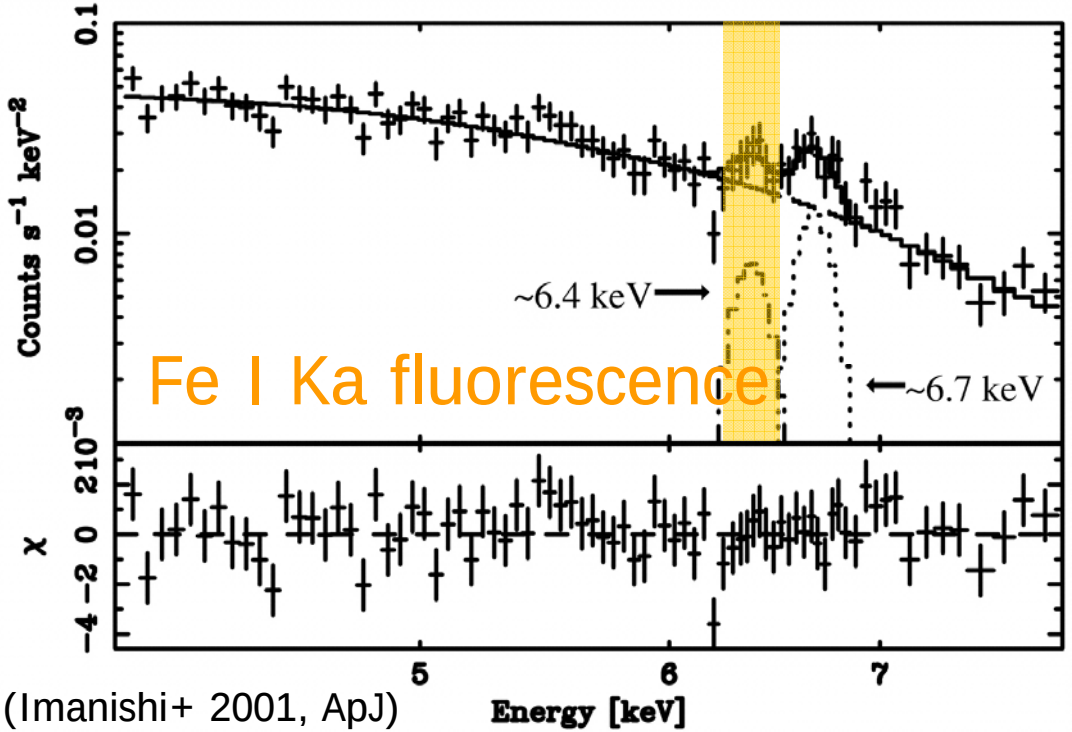
- How large are flares?
- How are proto-planetary disks effected?

2. A Case





(Imanishi+ 2001, ApJ)



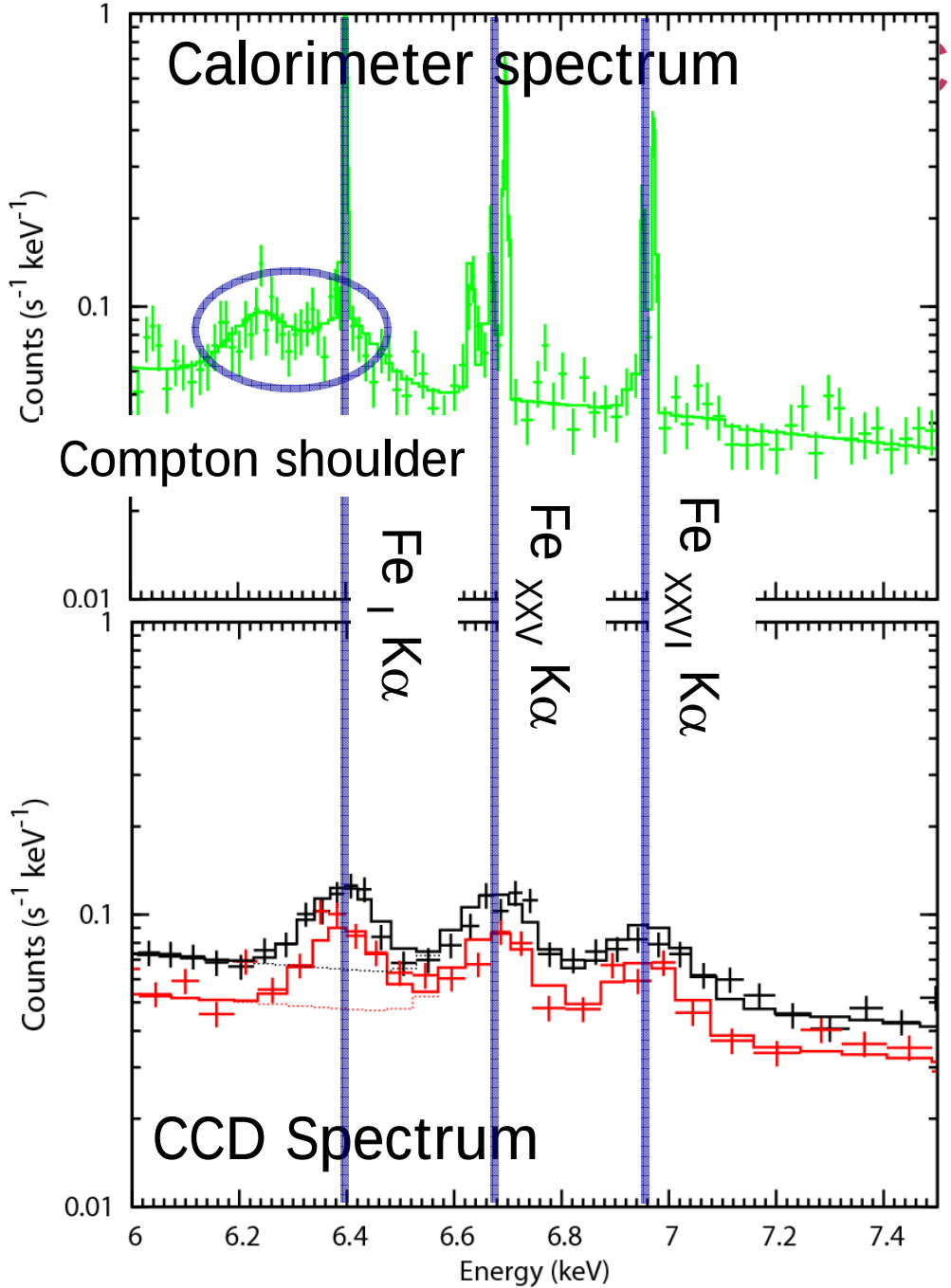
(Imanishi+ 2001, ApJ)

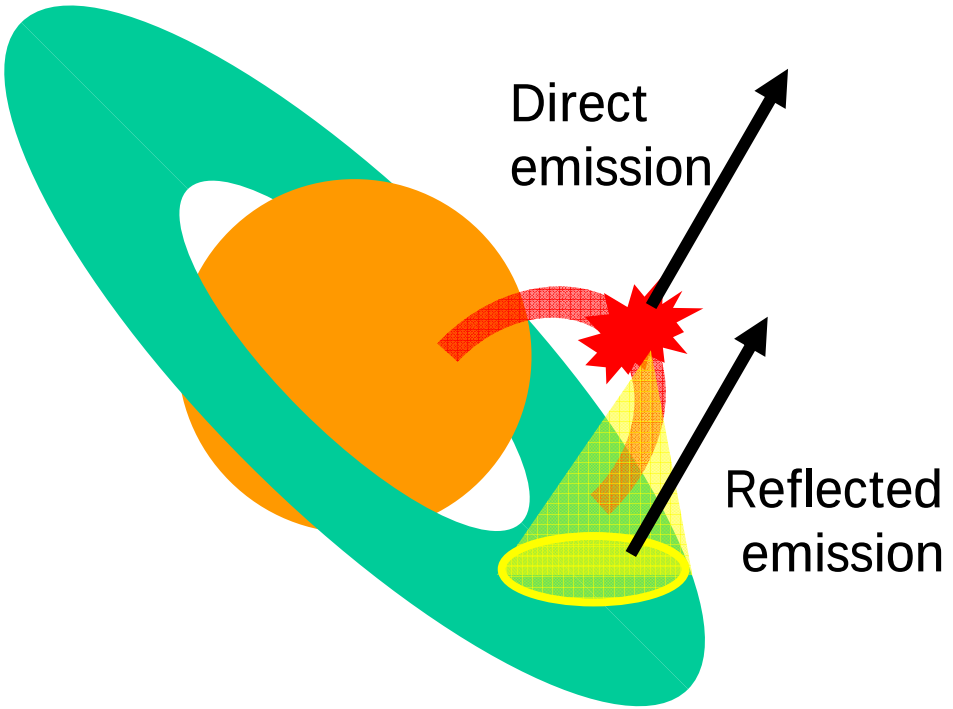
Any stars can cause such flares once in 2-3 days. A 100 ks observation will catch some flares.

*Stelzer, B. @ http://www.mpe.mpg.de/ot.

2. A Case Study (3/3)

--- CCD spectra ---





IXO will bring advances over Astro-H.

1. Large FoV (x3) -> more chance to catch flares.
2. Small PSF (x1/20) -> Little concern for confusion. Easy identification of stars.
3. Large Aeff (x20) -> reverberation mapping.

3. Summary

- Predictions for “hot topics”.

1. Jets and disks in young stars.
2. Evolved stars.
3. Non-thermal emission from active stellar flares.
4. Non-thermal emission in colliding-wind binaries (CWBs).
5. High-resolution spectroscopy of protostars, T Tauri stars.
6. Doppler tomography of X-ray active binaries.
7. X-rays from early-type stars: magnetic vs colliding-winds.

These are “predictable” phase II sciences. Unpredictable Phase I sciences will add more excitements.

- A case study of proto-planetary disks illuminated by flares.
  - IXO advances over Astro-H by x3 FoV, x1/20 PSF, x20 Aeff.