# Homework Assignment1 (for Astronomy Candidate)

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## 0. PRE-UP

### Initilization

Please do following steps by typing commands.

1. to initialize lmod

$> xspec$

$xspec > lmod\ relxill$ .

2. to go to your working directory

$xspec > cd\ your/working/directory/$

3. load model iron line

$xspec > model\ relline$

You may need to pick up some other useful commands for copying, pasting files, making directory etc. Please refer to following short guide.

http://mally.stanford.edu/ sr/computing/basic-unix.html

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Note

## 1. COMPILE YOUR CODES

Load model $RELLINE$ as above with default model parameters. Using your favorite plotting tool to plot following two pictures.

**plot 1.1**

3 lines $a_* = 0$, $i = 10$, 30, 70 deg

**plot 1.2**

11 lines $a_* = 0.0$, 0.2, 0.5, 0.8, 0.9, 0.99, $i = 30$ deg

**Hint 1.1:**

1. to change parameter
$xspec > newpar$ [$parameter\ number$]
$>$ [$double$] [$double$]
2. to open a plotting window
$xspec > cpd\ /xs$
3. to output data
$xspec > iplot\ model$
$PLT > wdata$ [$filename$]
4. open plotting window $/xs$
$xspec > cpd\ /xs$
5. to plot model
$xspec > plot\ model$

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Note

## 2. SPECTRUM OUTPUT AND EMISSIVITY INDEX

Read Chap 2.1, 2.2, 2.4 in T. Dauser(2013) and following page.
http://www.sternwarte.uni-erlangen.de/ dauser/research/relline/

### 2.1 Emissivity index

Find out which variable in RELLINE is this so called emissivity index in T. Dauser(2013). Redefine it as a broke powerlaw, replot 1.1 with $q1 = 10$, $r_{break} = 9m$ and explain why when $r$ is very large, the emissivity $q = 3$.

*Hint 2.1.1*

Broke powerlaw index is defined as

$$q = \begin{cases} q1, & r < r_{break} \\ 3, & r > r_{break} \end{cases} \tag{1}$$

*Hint 2.1.2*

when r is very large, the spacetime is approximated as flat.

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Note

## 3. Kα IRON LINE

### 3.1 Innermost stable circular orbit(ISCO)

1. Please refer to the top panel of FIG.1.

2. Explain the difference among different models with different spin parameters.

**Hint 3.1**

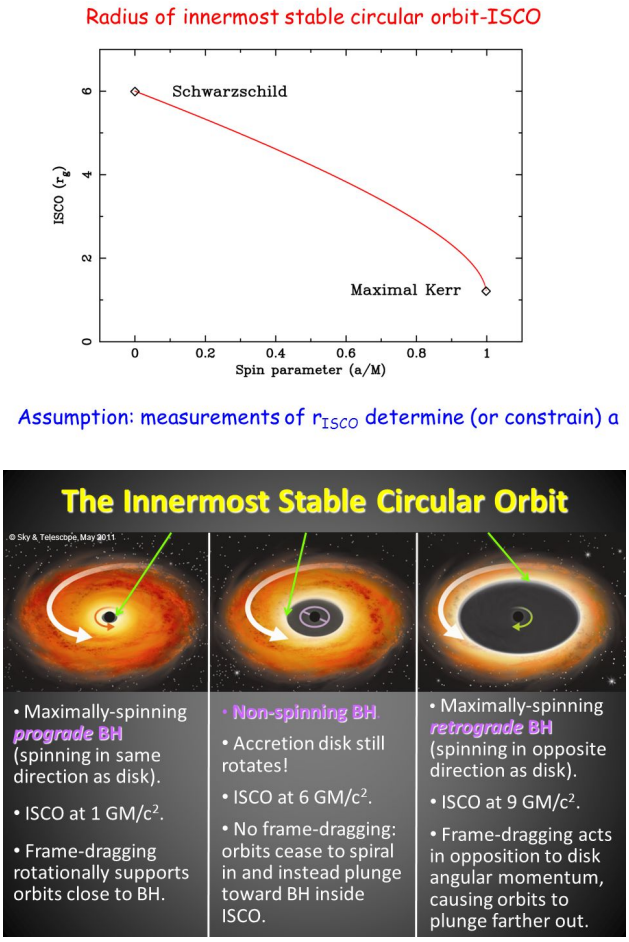


FIG. 1. ISCO vs. spin

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Note

### 3.2 Viewing angle

1. Recall the X-ray emission line you detected in your lab course. Scratch an iron line from a static source in your reference frame.

   Refer to http://phylab.fudan.edu.cn/doku.php?id=exp:xray

2. When the source is moving fast enough in flat spacetime, what the emission line should look like? Scratch an iron line from this source.

3. When the source is moving fast near black hole, what the emission line should look like? Compare your results with plot 1.1 and try to explain the difference.

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Note