

*Infrared Spectroscopy of the
Black Hole Candidate
GRO J1655-40*

Francis T. O'Donovan

based on

Infrared Observations of GRO J1655-40

Constraints on the Black Hole Mass

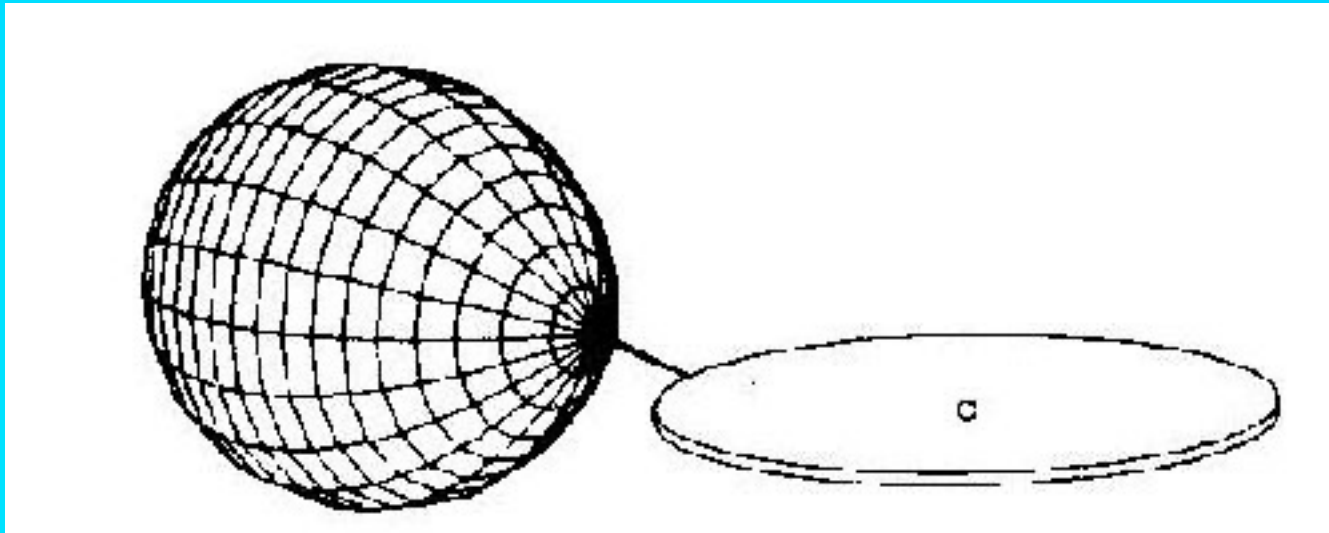
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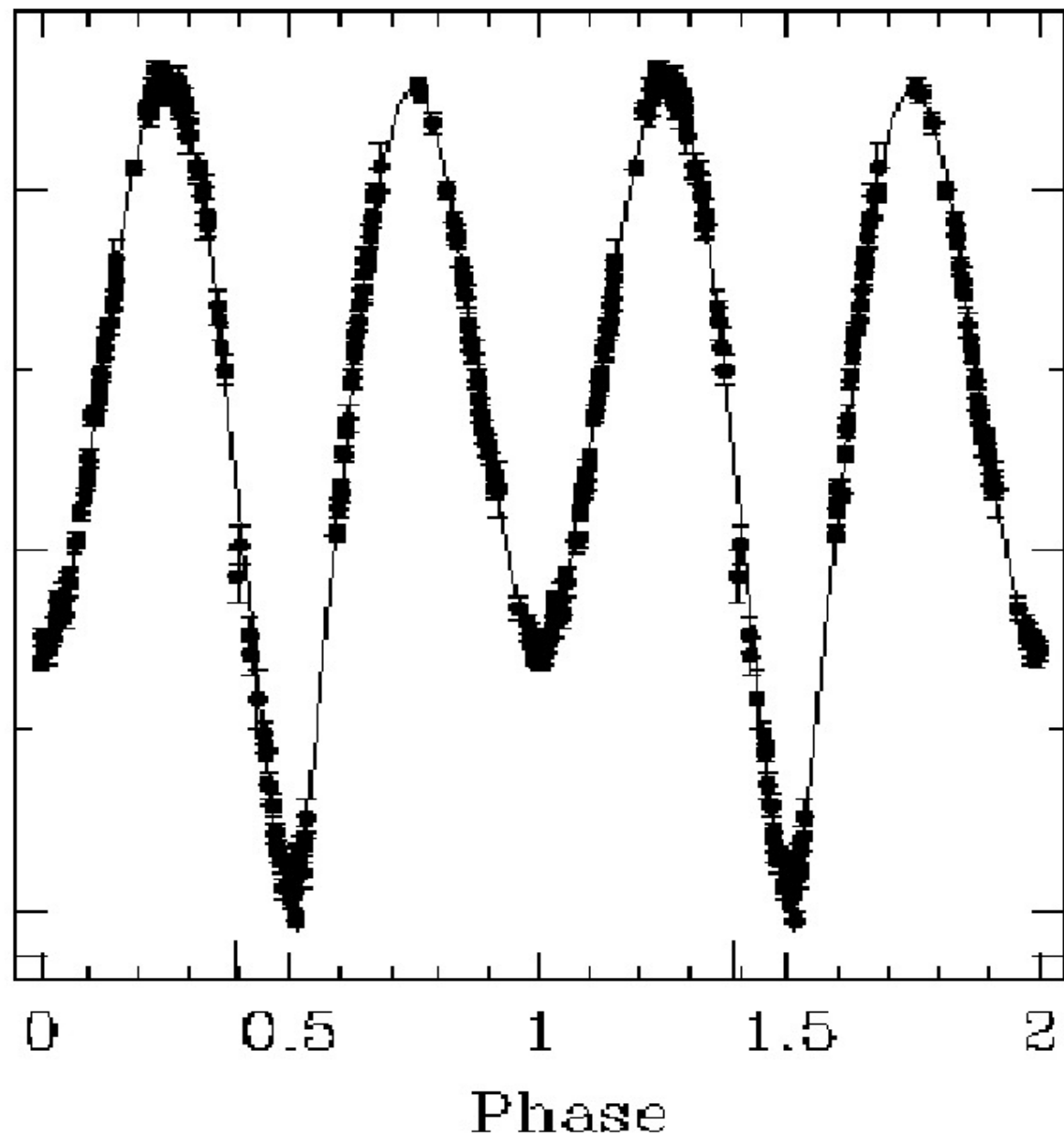
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Ay 101

- BH = remnant from death of a massive star.
- How observe? - Binary star systems!
- X-ray binaries.
- XT - X-ray Transient system.
- Light curve - **Ellipsoidal variability.**



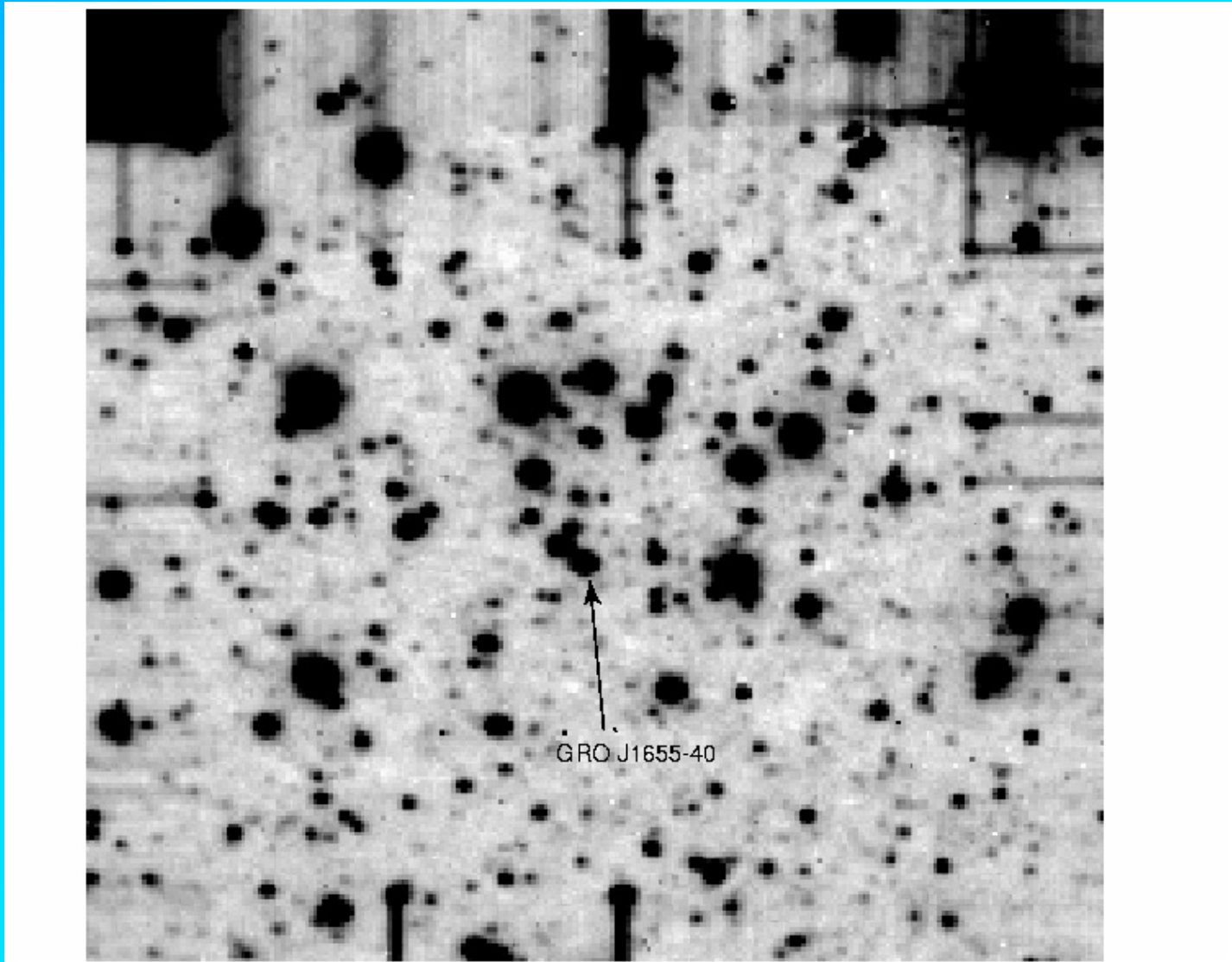


17.4 17.2 17

Magnitude

GRO J1655-40

- Discovered in July 1994 by CGRO.
- X-ray Transient. Harbors a BH?
- Superluminal jets. Model for AGN?!



166"x166" CTIO CIRIM image (K-band, 30s exposure)

Observations Made

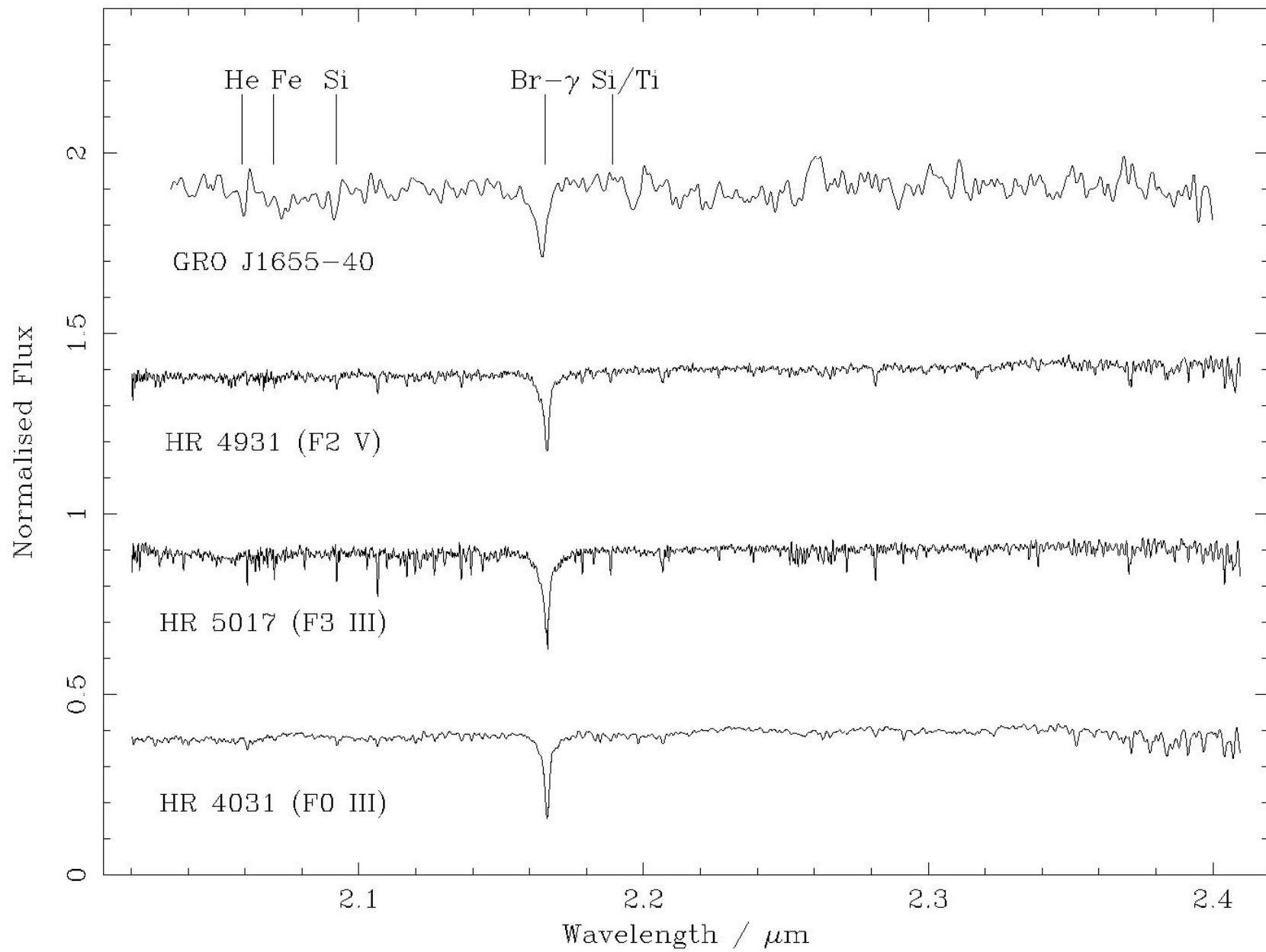
- Keck II NIRSPEC spectrograph.
- **First** high S/N ratio K-band (IR) spectrum of a BH XT system.
- Looking for disk emission.

Atomic Spectral Line

- **Br- γ** or HI (4-7) @ $\lambda = 21661.20\text{\AA}$.
- HeI (0-1) @ $\lambda = 20586.900\text{\AA}$.
- FeI (5-4) @ $\lambda = 20701.122\text{\AA}$.
- SiI (2-1) @ $\lambda = 21360.055\text{\AA}$.
- TiI] (2-3) @ $\lambda = 21890.0\text{\AA}$.

Spectroscopic Data Analysis

- Spectra of isolated stars from spectral atlas of Wallace & Hinkle (1997).



Spectroscopic Data Analysis

- Spectra of isolated stars from spectral atlas of Wallace & Hinkle (1997).
- Equivalent widths:
Absorption spectrum similar to that of a F5-F7 III-IV star.

Table 6.1: Equivalent widths of Br- γ feature

Identifier	Spectral Type	$W_\lambda/\text{\AA}$	Identifier	Spectral Type	$W_\lambda/\text{\AA}$
GRO J1655-40	F5-G0 III-IV	10 ± 1	HR 4931	F2 V	8 ± 1
HR 7495	F5 II-III	7.0 ± 0.5	HR 6927	F7 V	4.0 ± 0.5
HR 4031	F0 III	8.5 ± 0.5	HR 6608	G2 IIIb	3.0 ± 0.5
HR 5017	F3 III	8 ± 1	HR 7373	G8 IV	3 ± 1
HR 21	F2 IV	7 ± 1	HR 4375	G0 V	3 ± 1
HR 8905	F8 IV	4.5 ± 0.5	HR 483	G1.5 V	3.5 ± 0.5
HR 2943	F5 IV-V	6.5 ± 0.5	HR 7504	G3 V	3.0 ± 0.5

Table 6.2: Equivalent widths of weaker features

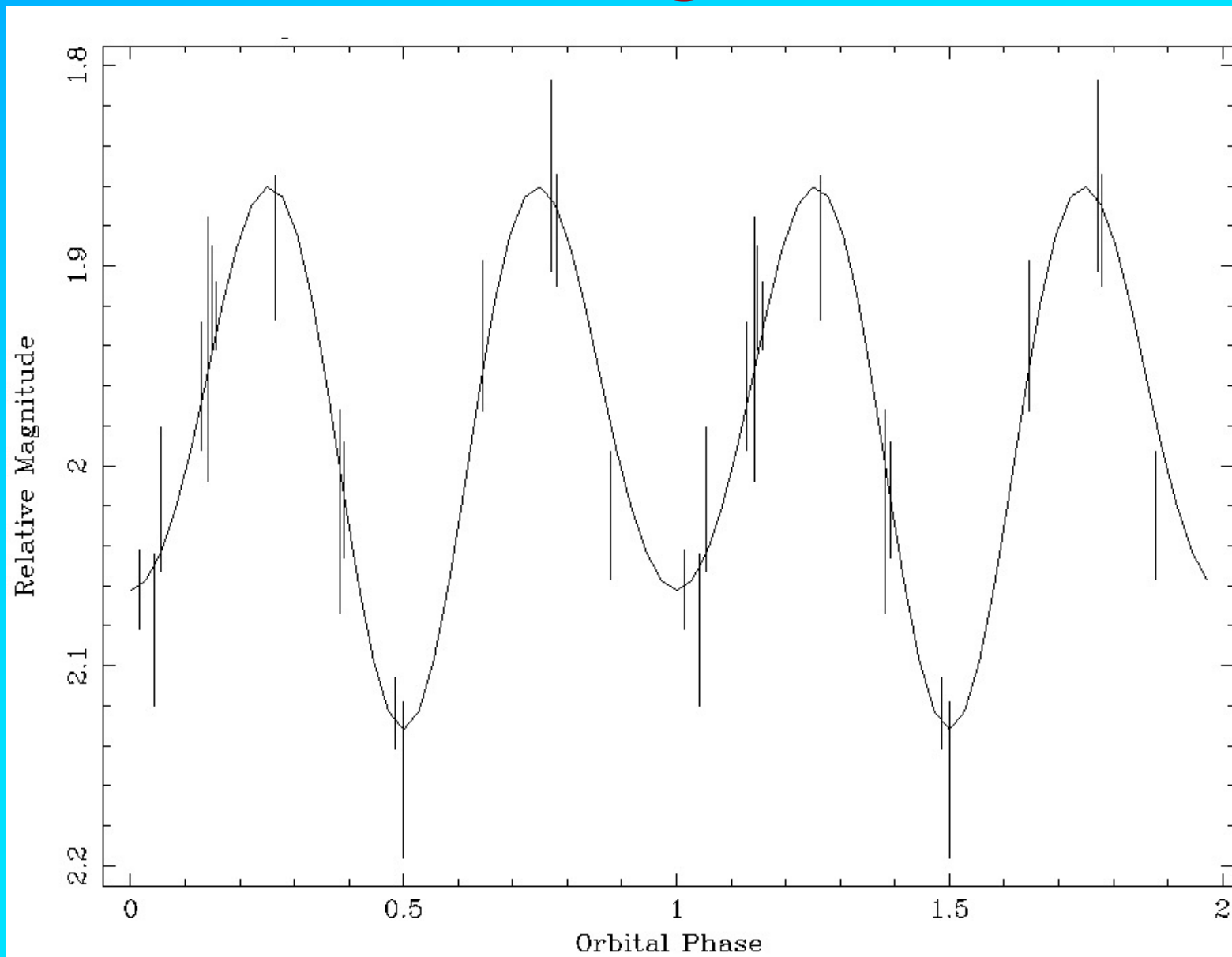
Identifier	He	Fe	Si	Si/Ti
GRO J1655-40	1.1 ± 0.2	0.8 ± 0.3	1.1 ± 0.2	0.5 ± 0.2
HR 4031	0.6 ± 0.1	0.4 ± 0.1	0.3 ± 0.1	0.4 ± 0.1
HR 5017	0.2 ± 0.1	0.6 ± 0.1	0.4 ± 0.1	0.5 ± 0.1
HR 4931	0.4 ± 0.2	0.5 ± 0.1	0.3 ± 0.1	0.3 ± 0.1

Spectroscopic Data Analysis

- Spectra of isolated stars from spectral atlas of Wallace & Hinkle (1997).
- Equivalent widths:
Absorption spectrum similar to that of a F5-F7 III-IV star.
- No emission \Rightarrow
negligible disk contribution!

Modeling

$$M_x \sim 7 M_s.$$



Comments and Conclusions

- Derived values comparable with previous studies.
- But a unique determination of disk contribution.