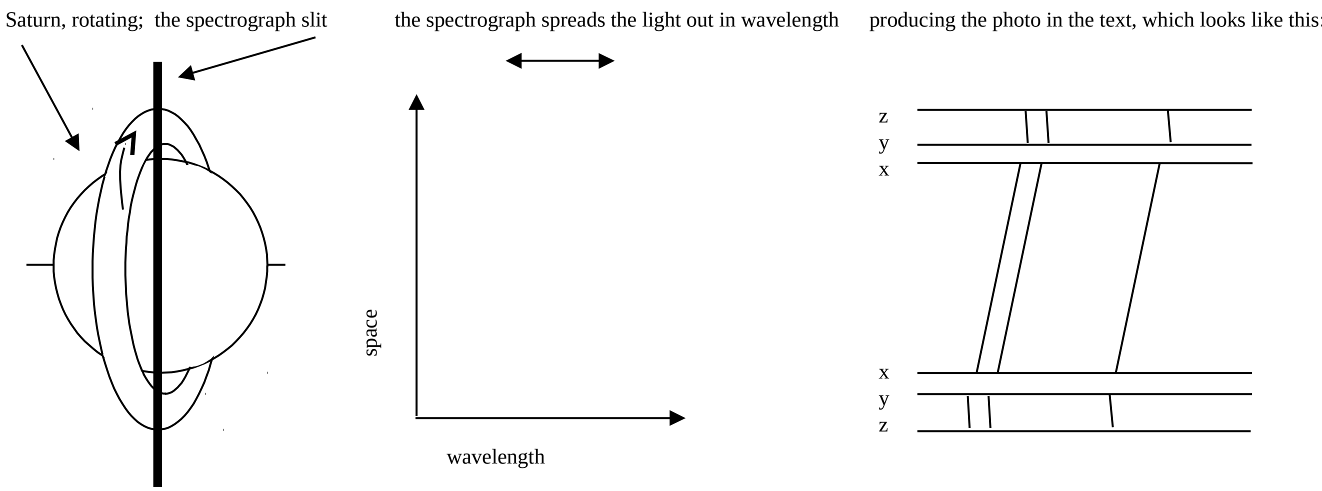
Name________________________________ Date_________________________

The Rotation of Saturn & Its Rings

These instructions supplement the instructions in *Sky and Telescope's* "Rotation of Saturn and Its Rings".

The geometry: The light that comes in through the spectrograph slit is spread out in wavelength to produce the spectrum; the vertical axis is spatial and the horizontal axis is wavelength.



The comparison lines are the bright Neon lines at the top and bottom of the spectrum. They are labeled with their wavelengths in Ångstroms. **Carefully draw** vertical lines across the spectra, connecting top and bottom of two sets of comparison lines.
Wavelengths of the comparison lines you are using: ________________________________

Measure the separation between these two comparison lines in mm: _____________________
Calculate the dispersion D of the spectrum: $D = \Delta\lambda / \Delta r$, where $\Delta\lambda$ is the wavelength difference in Å and Δr is the measured separation in mm. D = _______________

Choose five absorption lines near one of your comparison lines. **Measure the separation** in mm between an absorption line and one of your comparison emission lines (+ to the right of the comparison line, – to the left). Use calipers and measure to 0.05 mm accuracy. ***Make six measurements*** for each of the five absorption lines: Measure at the edges of Saturn's disk (x), at the inner edges of the rings (y), and at the outer edges of the rings (z) (refer to the sketch above). **Record your measurements** in the table on the worksheet. **Calculate the difference** between the top and bottom measurements for each line and then average your results.

Multiply your average differences in mm by the dispersion to get average differences in Å. Use the Doppler equation to turn these $\Delta\lambda$s into rotational velocities.

You'll see that the second table involves dividing $\Delta\lambda$ by 4, accounting for two separate factors of 2 when measuring absorption features in Saturn's atmosphere. The explanation in the Sky & Telescope article is cryptic; **fill in the following blanks** for a more basic explanation.
One factor of 2 stems from measuring the rotation using absorption features on both the ____________ side of the planet and the ____________ side of the planet. Another factor of 2 comes from using sunlight that is __________ off the surface of Saturn.

Distances:

the radius of Saturn is about 60,400 km;

the distance from the center of Saturn to the inside of the rings is about 92,000 km;

the distance from the center of Saturn to the outside edge of the rings is about 137,000 km.

Use these distances and your calculated velocities to **calculate rotation periods** for the disk of the planet and for the inside and outside edges of the rings.

As the text notes, the accepted equatorial rotation period for Saturn is 10^h14^m. **Comment on the accuracy of your result and likely sources of error**.

The ring particles orbit Saturn with periods that depend on their distances from the center of Saturn according to Kepler's 3rd law:

$$P^2 = \frac{4\pi^2}{G(M+m)} a^3 ,$$

where *a* is the distance between the two masses. **Calculate the ratio of the periods** of the inner to outer edges of the ring obtained from your measurements and compare it to that expected from Kepler's 3rd law.

Use your inner and outer ring periods and Kepler's 3rd law to **calculate the mass of Saturn**. **Average the two results and compare** with the accepted value of $5.7\ 10^{26}$ kg.

Saturn Rotation worksheet

Measurements: location:	line 1	line 2	line 3	line 4	line 5	average (mm):
top of disk (the x's)						
bottom of disk						
$\Delta\lambda$ difference (top – bottom)						
top inside of ring (the y's)						
bottom inside of ring						
$\Delta\lambda$ difference (top – bottom)						
top outside of ring (the z's)						
bottom outside of ring						
$\Delta\lambda$ difference (top – bottom)						

	$\Delta\lambda$ difference between top and bottom (Å)	$\Delta\lambda/4$	velocity (km/s)	rotation period (h)
disk of planet				
inside of ring				
outside of ring				

Comment on the accuracy of measured rotation period:

Ratio of inner to outer ring periods, measured:__________________

Ratio expected from Kepler's 3rd law:____________________; % difference:_____________

Mass calculated from inner rings:________________; from outer rings:______________

Average mass:__________________; % error: __________________