Applications of Calculus I
October 22, 2008

1. Methods for calculating a derivative in real life
2. Building a quantum star
3. Thinking four-dimensionally

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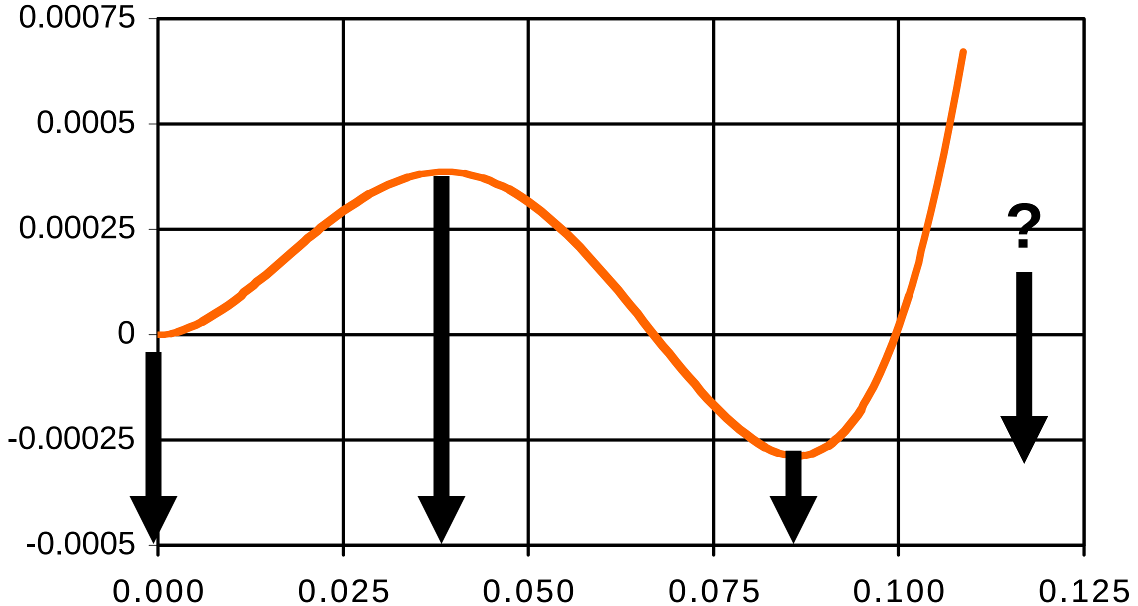
Our goal for this afternoon: central density and redshift in a quantum star

RECAP: critical points.



A. Global minimum energy, V_{min}

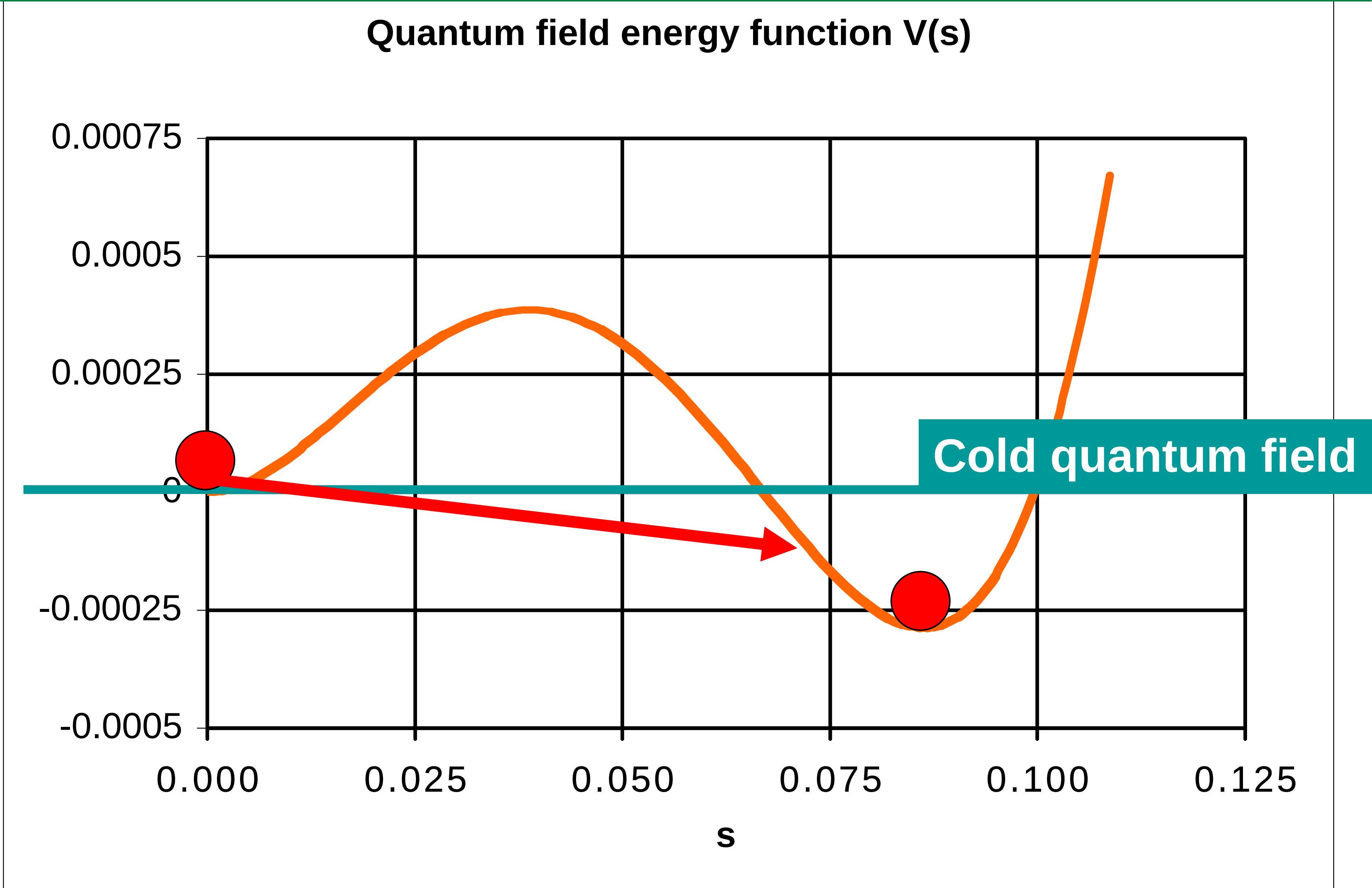
B. Global maximum energy, V_{max}

C. Local minimum energy

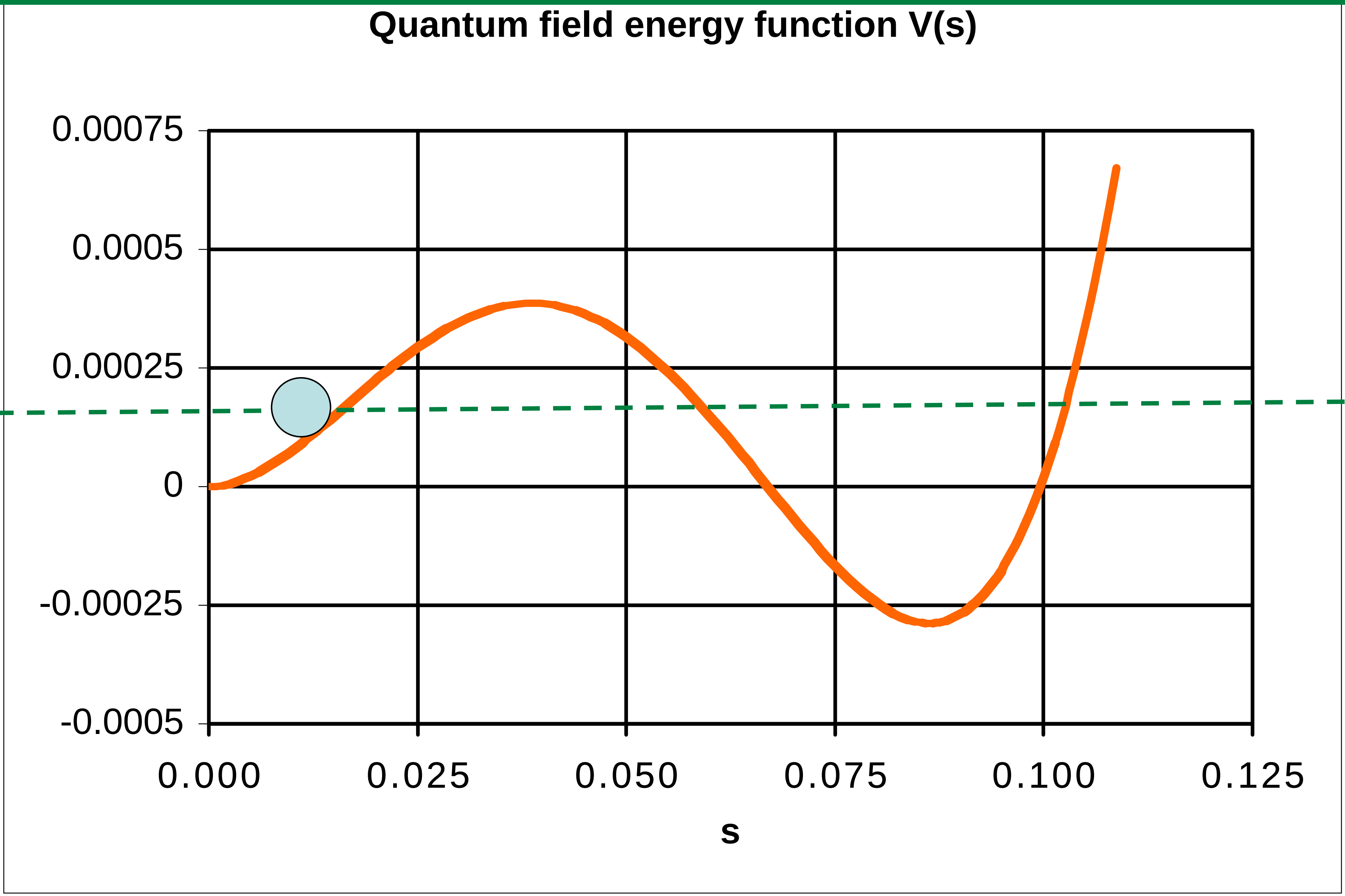
D. Local maximum energy

E. And the “height” of V(s) at each of these!!!

RECAP: tunneling



Building a quantum star

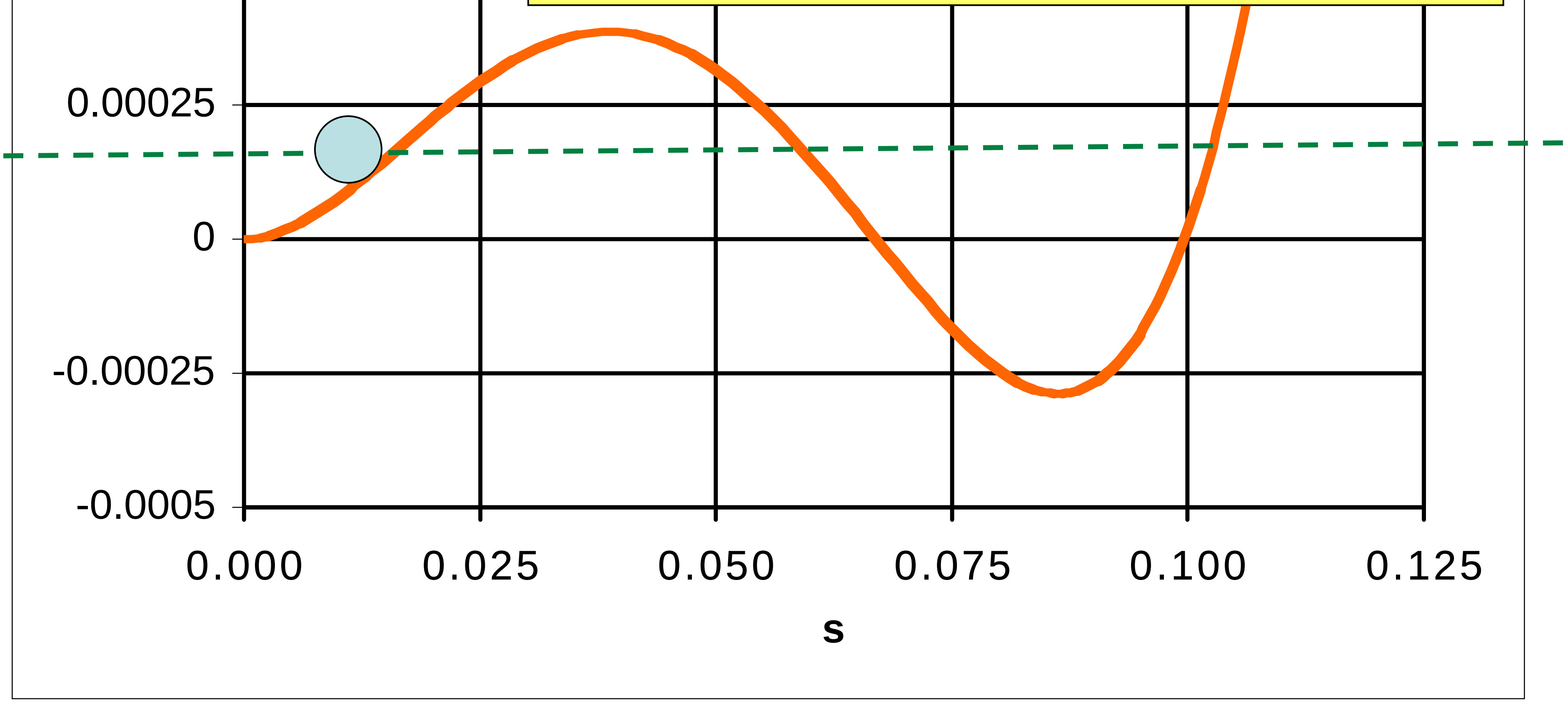


Building a quantum star

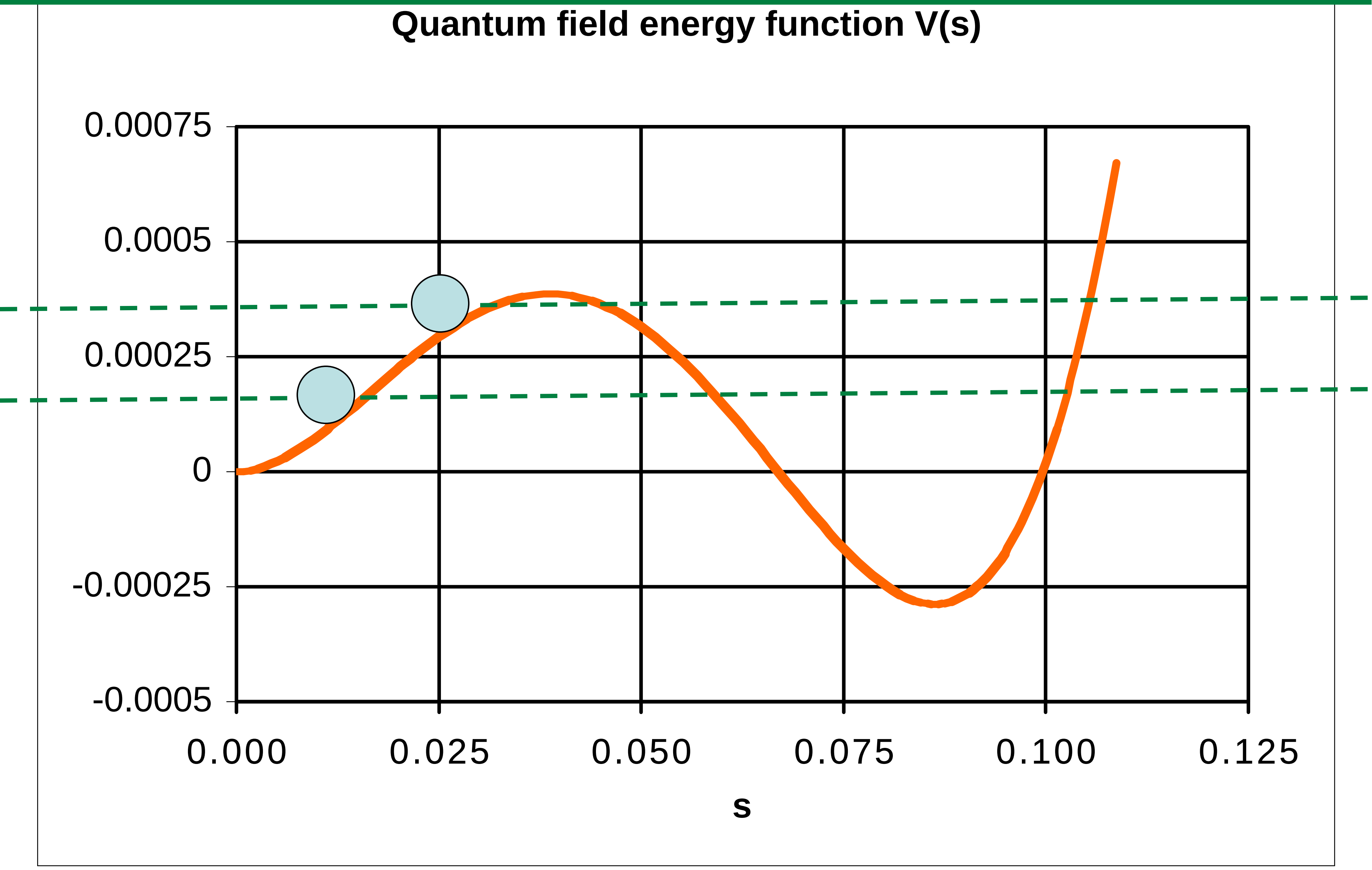
$$V(s) = s^2 - 2\eta s^3 + \tfrac{1}{2}\Lambda s^4$$

$\eta = 12.49$

$\Lambda = 300$



Building a quantum star: starting points

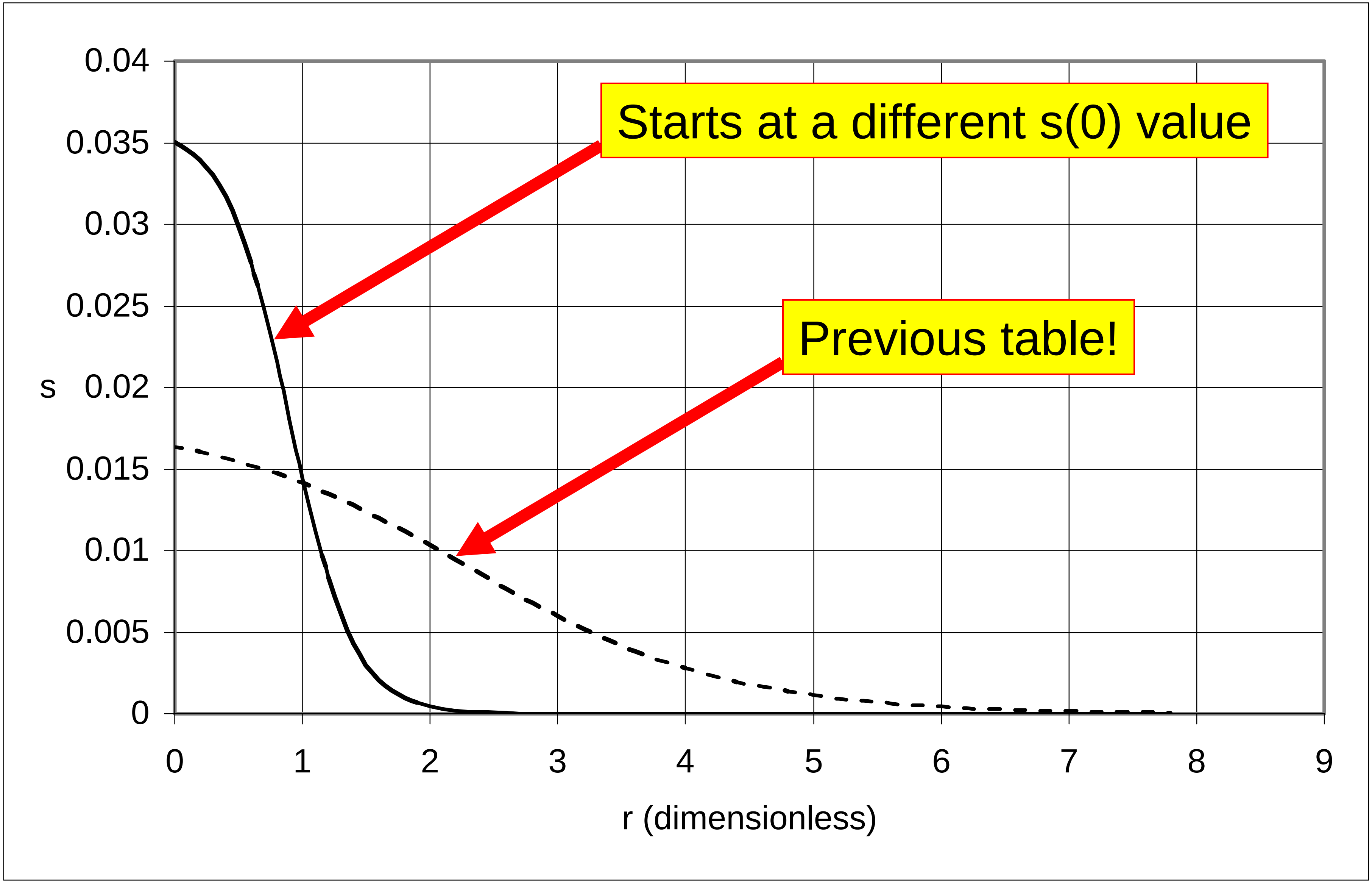


Building a quantum star: starting points

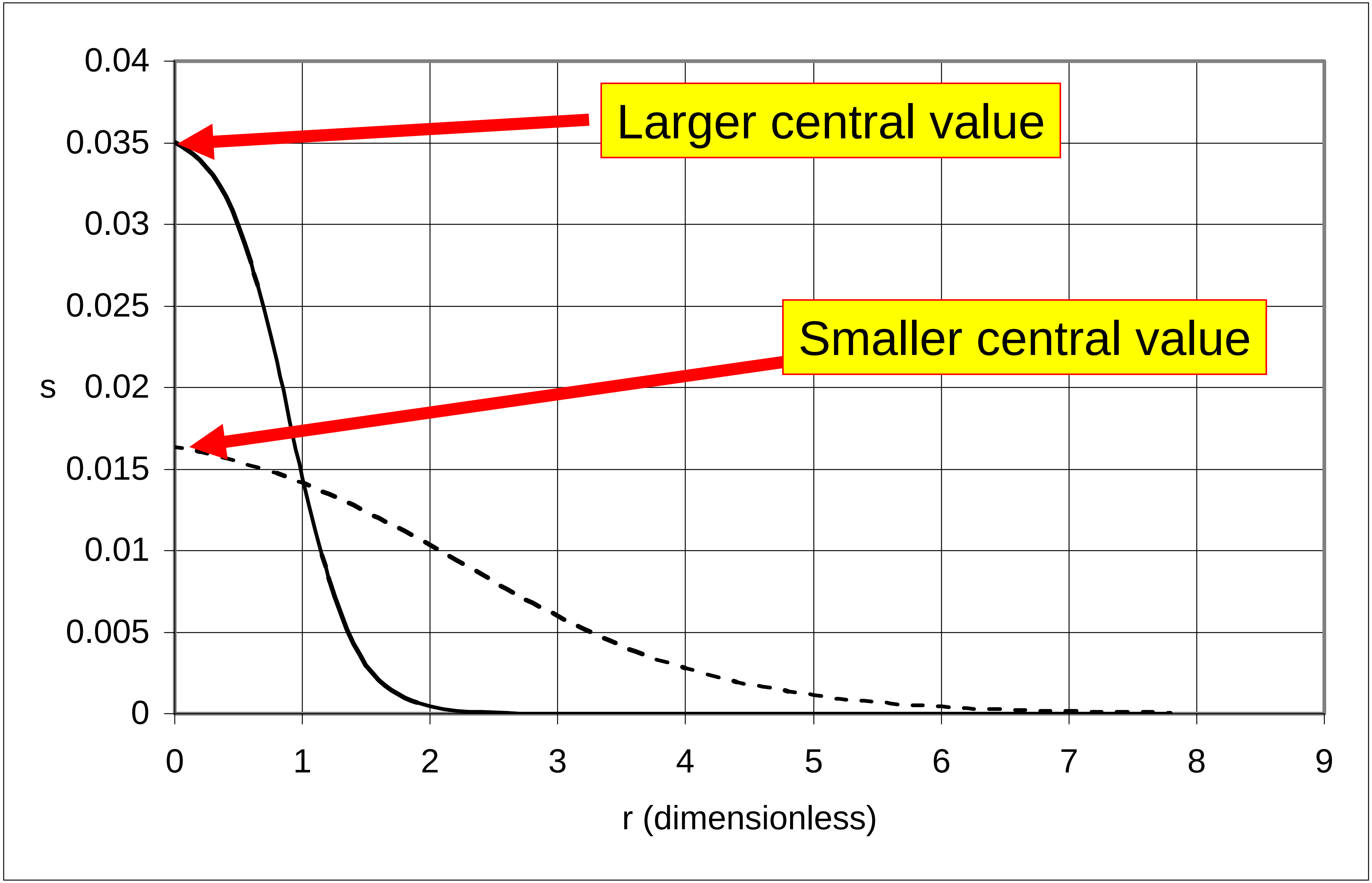
Position *r*	*Computational columns, s' etc.*		Field *s[r]*
0			0.0164 = s(0)
0 + dr			Next value of *s*
0 + 2dr			Etc.

What you start with here will determine the rest of s[r].

Building a quantum star: starting points



Building a quantum star: starting points



Central density

$$\rho = \alpha \left[\mathbf{s}(0) \right]^2$$

E.g., grams per cm^3

Strategy:

If your observational or lab work gives you reason to think that "clumps" of this field have a certain density, then it allows you to set up your table….

Maybe figure out a good prediction

Central density

Position *r*	*Computational columns, s' etc.*		Field *s[r]*
0			0.0164 = s(0)
			xt value of *s*
			.

Strategy:

If your observational or lab work gives you reason to think that "clumps" of this field have a certain density, then it allows you to set up your table….

Central density

Position *r*	*Computational columns, s' etc.*		Field *s[r]*
0			0.0164 = s(0)
			xt value of *s*
			.

Strategy:

… it allows you to set up your table and your table of derivatives does all the heavy lifting, to get you all other values of s[r].

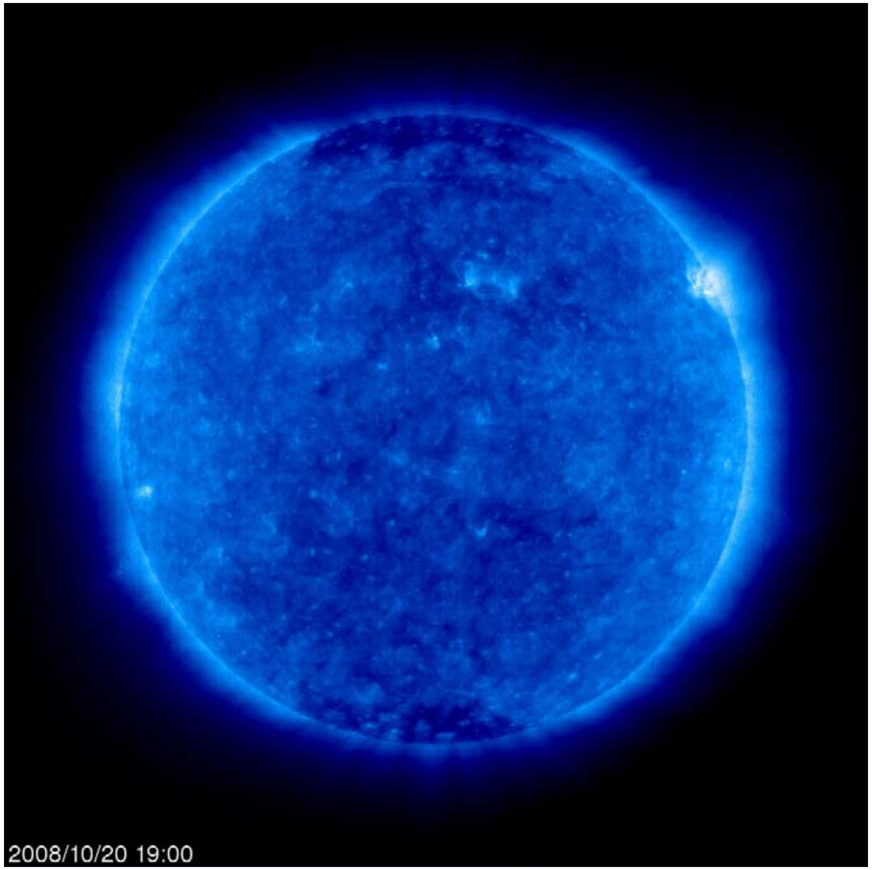
E.g., Klein-Gordon equation!

$$s'' - \frac{1}{c^2}\ddot{s} = \left[\frac{mc}{h}\right]^2 s(r)$$

Use derivatives to get s[r]!
Other columns in table!!!

U want this

Central redshift means …what?



Central redshift

A. If one works in curved spacetime, there is central redshift to worry about.
B. Gravity cannot change the speed of a photon…
C. But can change its frequency
   - ✓ I.e., its color.

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Two new functions, A[r] and B[r]

Table for curved space

Position *r*	***Comp***	Field *s[r]*	A[r]	B[r]
0		0.0164	1.00	0.0765
0 + dr		Next value		
0 + 2dr		Etc.		

Central redshift

1. Taking into account gravity, we will definitely see changes in the shape of s[r].
2. But now you have three starting values to think about and adjust.
3. Some values of s[0] make A and B drive everything into a black hole!
4. But the central redshift is the rough value of gravitational strength and…

Central redshift

5. Doppler shift of a photon of light IF it were emitted from the center of the star.
6. It is the inverse of the starting value of B!
7. 1/B(0)
8. So…pay attention to how you handle your derivatives!!!!!