A Smooth Bounce in Radiation Domination

Based on **arXiv:2505.08703** w/ Federico Piazza

Siméon Vareilles,
Centre de Physique Théorique, Marseille

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Schrödinger Equation in Quantum Cosmology

- **Add a proper-time clock DoF in Wheeler DeWitt $\mathcal{H}\Psi = 0$ constraint**: Schrödinger evolution in minisuperspace

$$\boxed{i\partial_t \Psi(q^a, t) = \mathcal{H}\Psi(q^a, t)}$$

- Applying it to a Radiation fluid model

$$I = -\frac{1}{\alpha H_\star}\int dt\, \frac{1}{2}\left(a\dot{a}^2 + H_\star^2\, a^{-1}\right)$$

- Semiclassical **time as a test-field** factorization

$$\Psi(a,t) \sim \exp\left[\underbrace{-\overbrace{\frac{(2H_\star t - a^2)^2}{4\sigma^2}}^{\text{expected: } a \sim t^{1/2}} + \frac{1}{4}\ln a}_{\mathcal{O}(\alpha^0)} - \underbrace{\frac{ia}{\alpha}}_{\mathcal{O}(\alpha^{-1})}\right]$$

Siméon Vareilles, arXiv:2505.08703

Analogy with the hydrogen atom

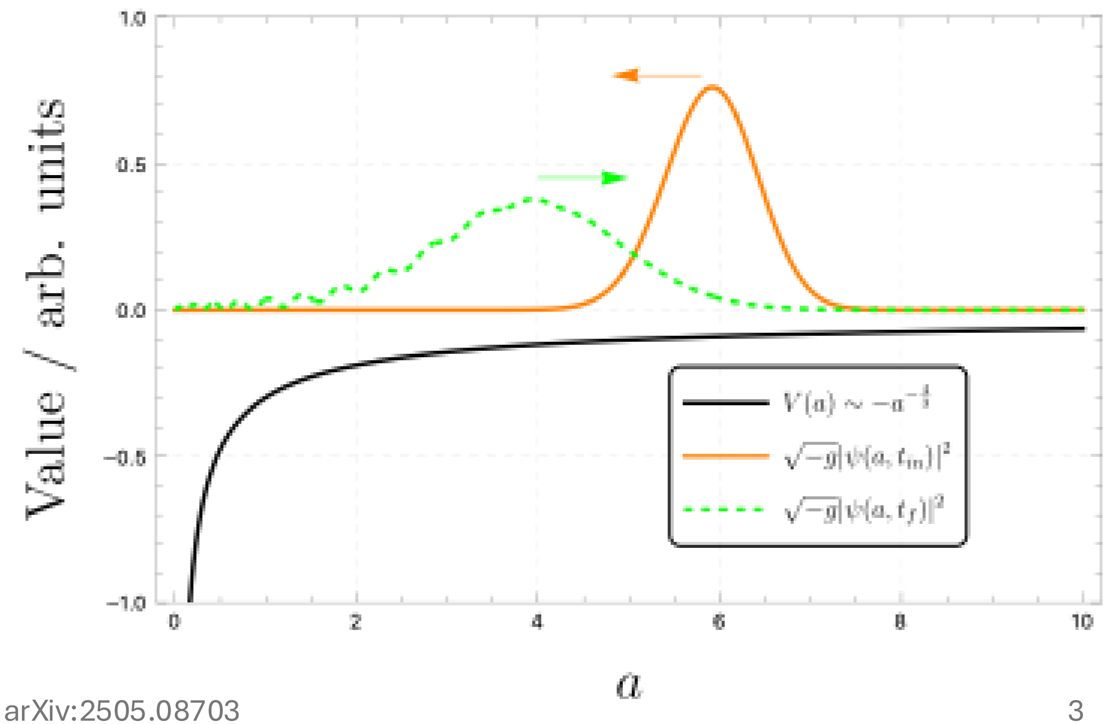
- Schrödinger equation in terms of the rescaled variable $x \sim a^{3/2}$

$$i\alpha H_\star^{-1}\partial_t\Psi(x,t) = -\frac{1}{2}\left(\alpha^2\partial_x^2 + x^{-\frac{2}{3}}\right)\Psi(x,t)$$

- Identical to an **s-wave** scattering off a central pot

$$\boldsymbol{V \sim -r^{-2/3}}$$

- **Initial**: Semiclassical WF imposed at $x \gg x_{\mathrm{bohr}} \sim \alpha^{3/2}$
- **Bound. conditions**: $\psi(0,t) = 0$ (Regularity at the origin)



Quantum bounce

- Initial (close-to) Gaussian wavepacket peakes on

$$a_{\mathrm{cl}}(t) \sim t^{1/2}$$

- As $t \to 0$, $\langle a \rangle$ departs from singularity collapse

- If $\Delta a \gg 1$, $a_{\min} \sim \Delta a \to$ **nearly α-independent.**
- Aspects of inflation already captured?