Supplemental material

The following two derivations are provided to supplement the main text of the *Letter*, and share the same notational conventions, equation and reference numbering.

The minisuperspace PGT$^{\mathbf{q},+}$. – For previous treatments of the minisuperspace formulation of PGT$^{\mathrm{q},+}$, see [21, 48]. We use an ADM-like interval $\mathrm{d}s^2 = u^2(\mathrm{d}t^2 - v^2\mathrm{d}\mathbf{x}^2)$, where the flat FRW interval in (6) is recovered by taking $u \mapsto 1$ and $v \mapsto a$. The analogue defined in (9) corresponds to the following choices of gauge

$$b^a{}_\mu = u\big(v(\delta^a_\mu - \delta^a_0\eta_{0\mu}) + \delta^a_0\eta_{0\mu}\big), \quad A^{ab}{}_\mu = uv\delta^d_0\big(2\phi\delta^{[b}_\mu\delta^{a]}_d - \tfrac{1}{2}\psi\varepsilon_{\mu d}{}^{ab}\big). \tag{S1}$$

The gauge fields in (S1) are then substituted into (3a) and (3b), and then into (4). Once the Gauss-Bonnet term is discarded as a total time derivative, the coupling constants defined in (10) may be used to express the reduced Lagrangian as

$$\begin{aligned}\bar{L}_{\mathrm{T}} = {}&(-3\sigma_2 u^2 v\psi^2 + 24\sigma_3 u^2 v\phi^2 + 3\sigma_3 u^2 v\psi^2 + 3m_{\mathrm{P}}{}^2\upsilon_2 u^2 v)(\partial_t v)^2 + (-6\sigma_2 uv^2\psi^2 + 48\sigma_3 uv^2\phi^2 + 6\sigma_3 uv^2\psi^2 + \\ &6m_{\mathrm{P}}{}^2\upsilon_2 uv^2)\partial_t v\partial_t u + 48v^2\sigma_3 u^2\phi\partial_t v\partial_t\phi + (-6\sigma_2 u^2 v^2\psi + 6\sigma_3 u^2 v^2\psi)\partial_t v\partial_t\psi + (-3\sigma_2 v^3\psi^2 + 24\sigma_3 v^3\phi^2 + \\ &3\sigma_3 v^3\psi^2 + 3m_{\mathrm{P}}{}^2\upsilon_2 v^3)(\partial_t u)^2 + 48v^3\sigma_3 u\phi\partial_t u\partial_t\phi + (-6\sigma_2 uv^3\psi + 6\sigma_3 uv^3\psi)\partial_t u\partial_t\psi + 24v^3\sigma_3 u^2(\partial_t\phi)^2 + \\ &(-3\sigma_2 u^2 v^3 + 3\sigma_3 u^2 v^3)(\partial_t\psi)^2 + (-48\sigma_1 u^3 v^3\phi^2 + 12\sigma_1 u^3 v^3\psi^2 - 3m_{\mathrm{P}}{}^2\alpha_0 u^3 v^3)\partial_t\phi + (-48\sigma_1 u^3 v^2\phi^3 + \\ &12\sigma_1 u^3 v^2\phi\psi^2 - 3m_{\mathrm{P}}{}^2\alpha_0 u^3 v^2\phi + 6m_{\mathrm{P}}{}^2\upsilon_2 u^3 v^2\phi)\partial_t v + (-48\sigma_1 u^2 v^3\phi^3 + 12\sigma_1 u^2 v^3\phi\psi^2 - \\ &3m_{\mathrm{P}}{}^2\alpha_0 u^2 v^3\phi + 6m_{\mathrm{P}}{}^2\upsilon_2 u^2 v^3\phi)\partial_t u + 3m_{\mathrm{P}}{}^2\upsilon_2 v^3 u^4\phi^2 + 3v^3 m_{\mathrm{P}}{}^2\alpha_0 u^4\phi^2 + 24v^3\sigma_3 u^4\phi^4 + \\ &3v^3 u^4\psi^2 m_{\mathrm{P}}{}^2\upsilon_1 - 3/4v^3 m_{\mathrm{P}}{}^2\alpha_0 u^4\psi^2 + 3/2v^3\sigma_3 u^4\psi^4 - 12\sigma_2 v^3 u^4\phi^2\psi^2 + \bar{L}_{\mathrm{m}}(\Phi,\Psi;u,v,\phi,\psi).\end{aligned} \tag{S2}$$

The first-order terms associated with the non-canonical sector of the full MA in (12) are now explicit in (S2).

The autonomous system. – The variables x and y encode the momentum and position of the canonical inflaton ξ. The *Cuscuton* ζ constrains the system, and is described by the single variable $z^2 = m_{\mathrm{p}}{}^2W^4\zeta^2/4H^2$. We also define $\lambda = -m_{\mathrm{p}}\partial_\xi V_{\mathrm{T}}/V_{\mathrm{T}}$ and $\mu = W$. While μ is convenient for the specific system in (15), variables x, y and λ are conventional parameters, and we will see presently that z is analogous to the conventional matter parameter [52, 63]. The pressure–$g_{\mu\nu}$ and ξ equations of (15) are expressed as a coupled first order system in terms of these variables

$$\begin{aligned}\partial_\tau x = {}&\big(-16\sqrt{2}\mu xy^2 + 6\sqrt{2}\mu^3 xy^2 - 2\sqrt{3}\lambda\mu^3 x^2y^2 + 16\sqrt{2}\mu xy^4 - 6\sqrt{2}\mu^3 xy^4 - \sqrt{2}\mu^5 xy^4 + 32xz^2 + 16\sqrt{2}\mu xz^2 - \\ &2\sqrt{2}\mu^3 xz^2 - 32xy^2z^2 - 32\sqrt{2}\mu xy^2z^2 + 2\sqrt{2}\mu^3 xy^2z^2 + 8\mu^4 xy^2z^2 + 2\sqrt{2}\mu^5 xy^2z^2 - \sqrt{6}\lambda\mu^4 x^2y^2z^2 + \\ &32xz^4 + 16\sqrt{2}\mu xz^4 - 4\mu^4 xz^4 - \sqrt{2}\mu^5 xz^4\big)/\big(-2\sqrt{2}\mu^3 + 2\sqrt{2}\mu^3y^2 + \sqrt{2}\mu^5y^2 - 4\mu^4z^2 - \sqrt{2}\mu^5z^2\big),\end{aligned} \tag{S3a}$$

$$\begin{aligned}\partial_\tau y = {}&\big(16\sqrt{2}y - 6\sqrt{2}\mu^2 y + 2\sqrt{3}\lambda\mu^2 xy - 32\sqrt{2}y^3 + 12\sqrt{2}\mu^2y^3 + \sqrt{2}\mu^4y^3 - 2\sqrt{3}\lambda\mu^2xy^3 + 16\sqrt{2}y^5 - \\ &6\sqrt{2}\mu^2y^5 - \sqrt{2}\mu^4y^5 + 32\sqrt{2}yz^2 - 2\sqrt{2}\mu^2yz^2 - 12\mu^3yz^2 - 3\sqrt{2}\mu^4yz^2 + 2\sqrt{6}\lambda\mu^3xyz^2 + \sqrt{3}\lambda\mu^4xyz^2 - \\ &32\sqrt{2}y^3z^2 + 2\sqrt{2}\mu^2y^3z^2 + 12\mu^3y^3z^2 + 2\sqrt{2}\mu^4y^3z^2 - \sqrt{6}\lambda\mu^3xy^3z^2 + 16\sqrt{2}yz^4 - 4\mu^3yz^4 - \\ &\sqrt{2}\mu^4yz^4\big)/\big(-2\sqrt{2}\mu^2 + 2\sqrt{2}\mu^2y^2 + \sqrt{2}\mu^4y^2 - 4\mu^3z^2 - \sqrt{2}\mu^4z^2\big).\end{aligned} \tag{S3b}$$

The dimensionless Hubble time is $\mathrm{d}\tau = H\mathrm{d}t$. To obtain the autonomous system in x and y we must eliminate λ, μ and z. We use (15b) and (15c) to solve for λ in terms of μ

$$\lambda = -\frac{2\sqrt{2/3}\big(8\Lambda_{\mathrm{b}} + 20m_{\mathrm{p}}{}^2\upsilon_1/\sigma_1 + (\Lambda_{\mathrm{b}} + 4m_{\mathrm{p}}{}^2\upsilon_1/\sigma_1)\mu^2\big)\sqrt{16 + 10\mu^2 + \mu^4}}{(8+\mu^2)\big(8\Lambda_{\mathrm{b}} + 8m_{\mathrm{p}}{}^2\upsilon_1/\sigma_1 + (\Lambda_{\mathrm{b}} + 4m_{\mathrm{p}}{}^2\upsilon_1/\sigma_1)\mu^2\big)}, \tag{S4}$$

Note that this explicitly incorporates the bare cosmological constant Λ_{b} and the central combination $m_{\mathrm{p}}{}^2\upsilon_1/\sigma_1$, which are on an equal footing. The ζ equation, which we gave explicitly in (16), reduces to a quartic in μ

$$(x^1 - 1)\mu^4 + 2\sqrt{2}z\mu^3 + 2(5x^2 - z^2)\mu^2 + 16x^2 = 0. \tag{S5}$$

Finally z is eliminated for x and y by the density–$g_{\mu\nu}$ equation

$$x^2 + y^2 - z^2 = 0. \tag{S6}$$

Note that (S6) *expells* the physical portions of the phase space from the unit disc, while a conventional matter parameter would *confine* them there. The quartic roots of (S5) cause the fully autonomous system to be unwieldy. Note that this is a generic feature of Class ^{2}A* and Class ^{3}C*, rather than of the MA formalism.