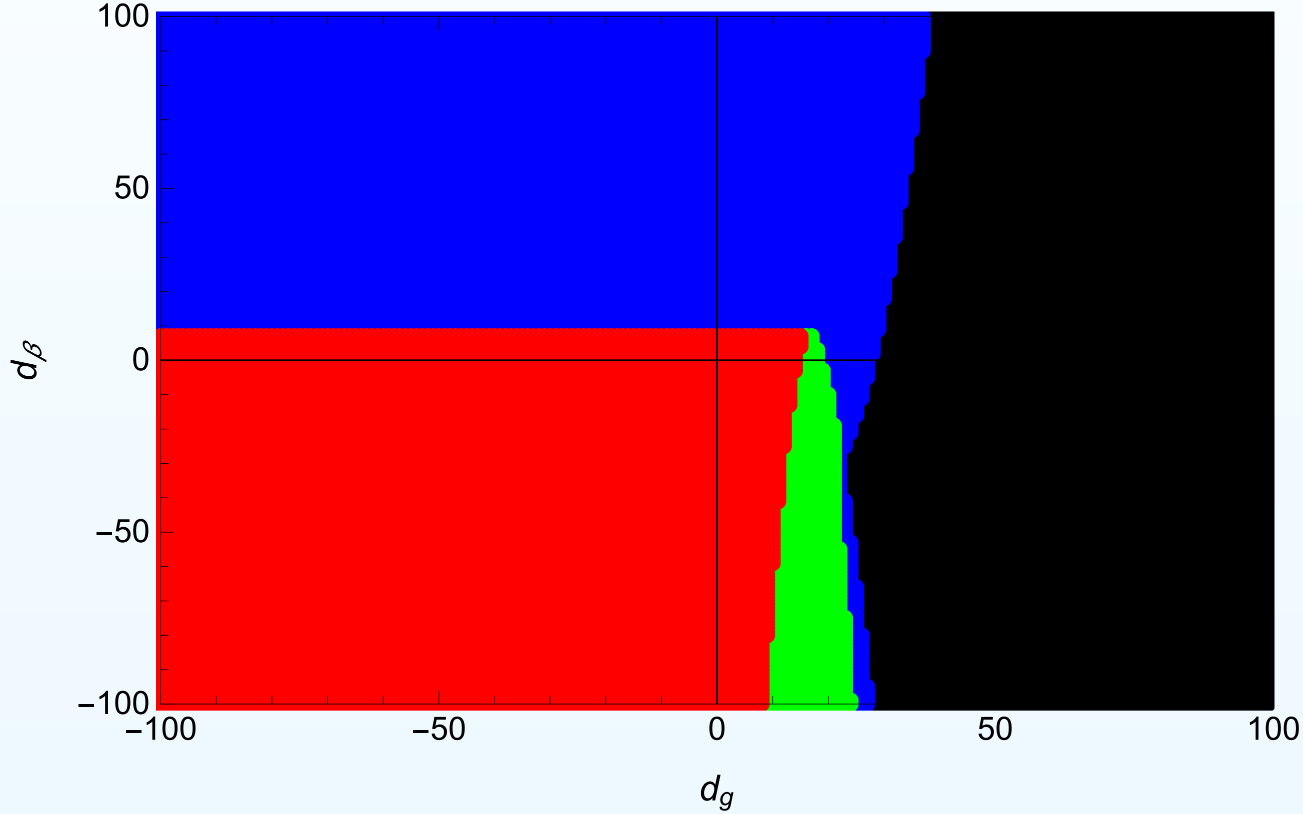
scanning for NGFPs: $N = 2$, Type II

deformation parameters in beta functions for g^1, g^2:

$$d_g = \frac{5}{4} N_S - \frac{7}{2} N_V + N_D \,, \qquad d_\beta = N_S + 2 N_V$$



black: 0 NGFP

blue: 1 NGFP

green: 2 NGFPs

red: 3 NGFPs

gravity + standard model matter: the stable NGFP

N	g^0_*	g^1_*	g^2_*	$g^3_* \times 10^{-4}$	$g^4_* \times 10^{-4}$	$g^5_* \times 10^{-4}$
1	-7.2917	-5.8264				
2	-6.7744	-5.2122	1.1455			
3	-6.7795	-5.2617	1.1601	50.466		
4	-6.7737	-5.2577	1.1550	49.161	-2.7013	
5	-6.7742	-5.2598	1.1559	51.122	-2.4926	0.3313
6	-6.7755	-5.2611	1.1571	51.929	-1.9180	0.4268
7	-6.7764	-5.2632	1.1582	53.712	-1.5336	0.7152
8	-6.7775	-5.2646	1.1592	54.700	-1.0696	0.8557
9	-6.7781	-5.2657	1.1599	55.663	-0.7932	1.0079
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$

- fixed point position rapidly converges
- g^i_*, $i \geq 3$, decrease rapidly

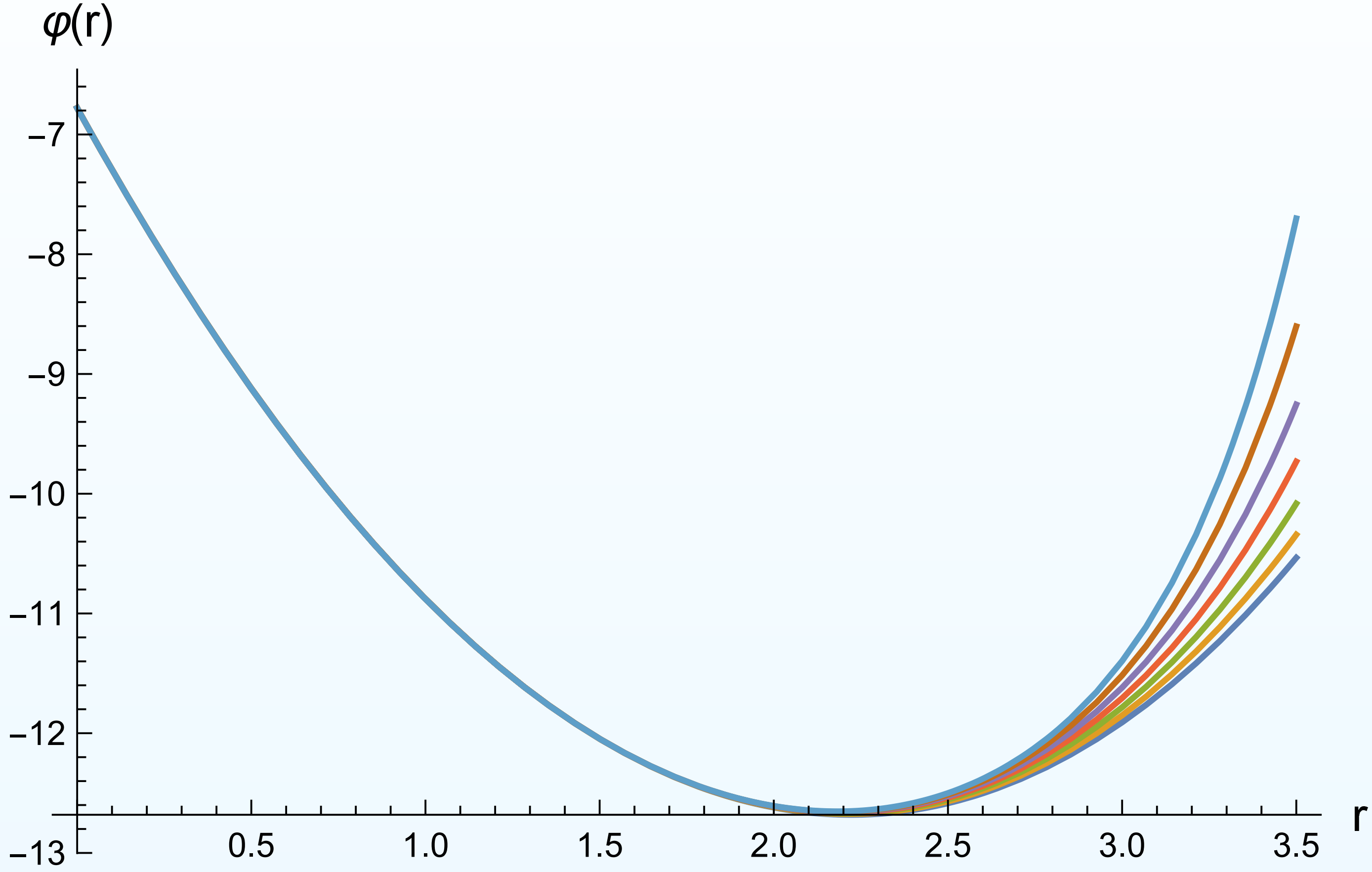
gravity + standard model matter: the stable NGFP

N	θ_0	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6
1	4	2.12					
2	4	2.33	-1.67				
3	4	2.27	-1.73	-6.01			
4	4	2.27	-1.81	-5.91	-9.31		
5	4	2.28	-1.81	-5.93	-9.33	-11.96	
6	4	2.27	-1.80	-5.92	-9.30	-12.15	-14.29
7	4	2.27	-1.79	-5.89	-9.28	-12.07	-14.63
8	4	2.27	-1.78	-5.87	-9.25	-12.06	-14.52
9	4	2.27	-1.78	-5.86	-9.23	-12.02	-14.51

- stability coefficients rapidly converge
- all θ_i are real
- finite number of fundamental parameters

gravity + standard model matter (polynomial solution)

polynomials with $N = 8, \ldots, 14$



- radius of converges set by moving singularity $\varphi'(r) = 0$

gravity + phenomenologically interesting matter sectors

- Type I regulator ($\alpha = 0$ in all sectors)

model	matter content			test	
	N_S	N_D	N_V	EH	$f(R)$
pure gravity	0	0	0	✓	✓
Standard Model (SM)	4	$\frac{45}{2}$	12	✓	✓
SM, dark matter (dm)	5	$\frac{45}{2}$	12	✓	✓
SM, $3\,\nu$	4	24	12	✓	✓
SM, $3\,\nu$, dm, axion	6	24	12	✓	✓
MSSM	49	$\frac{61}{2}$	12	✓	✓
SU(5) GUT	124	24	24	X	X
SO(10) GUT	97	24	45	X	X

gravity + phenomenologically interesting matter sectors

- Type ID regulator ($\alpha_D^M = -\frac{1}{4} \Longleftrightarrow \Box_D = \not{D}^2$)

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	N_S	N_D	N_V	EH	$f(R)$
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gravity + phenomenologically interesting matter sectors

- Type II regulator (removes all curvature terms from propagators)

model	matter content			test	
	N_S	N_D	N_V	EH	$f(R)$
pure gravity	0	0	0	✓	✓
Standard Model (SM)	4	$\frac{45}{2}$	12	✓	(X)
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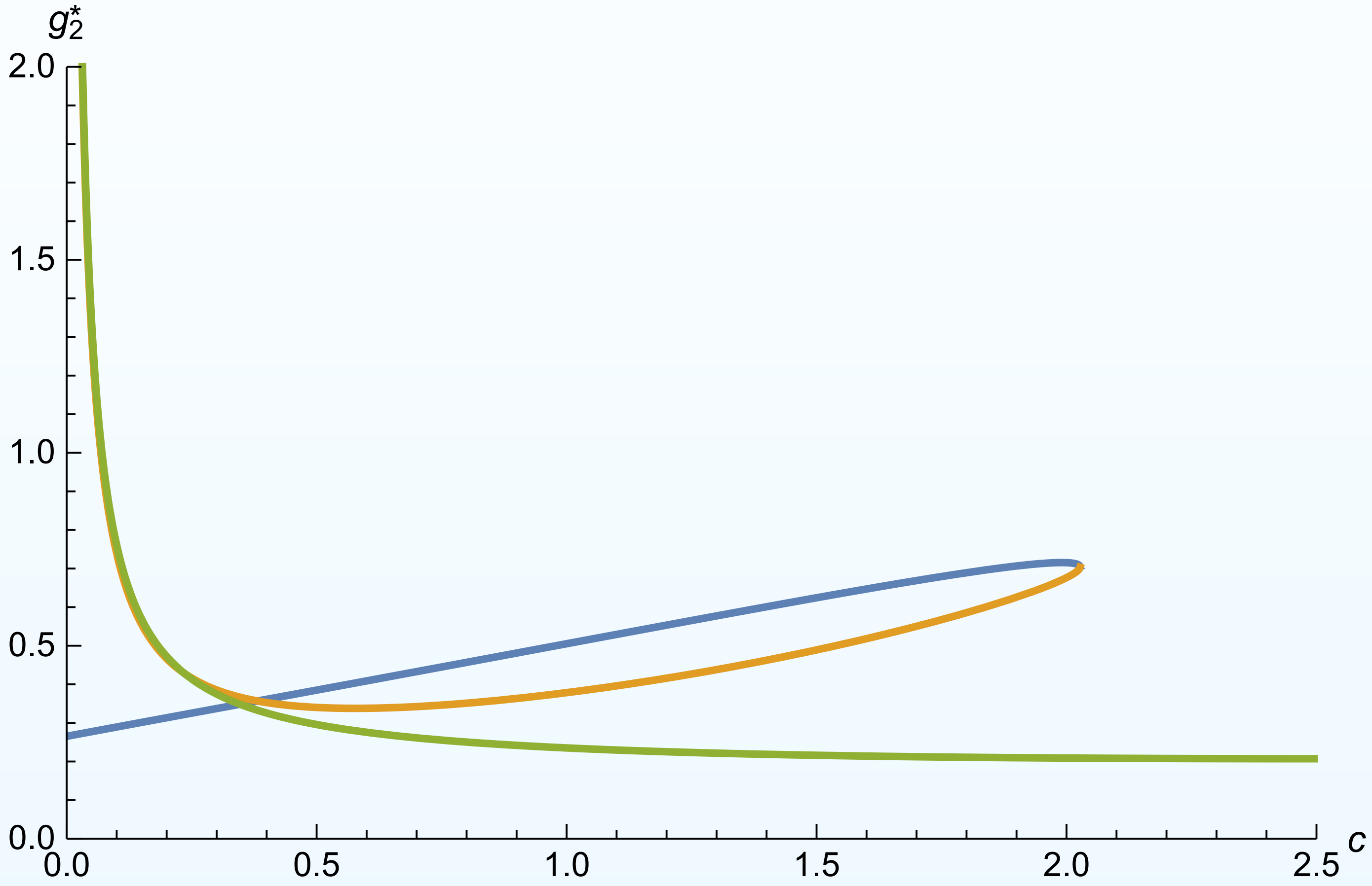
Deforming gravity-matter fixed points ($N = 2$)

pure gravity



$c = 0$

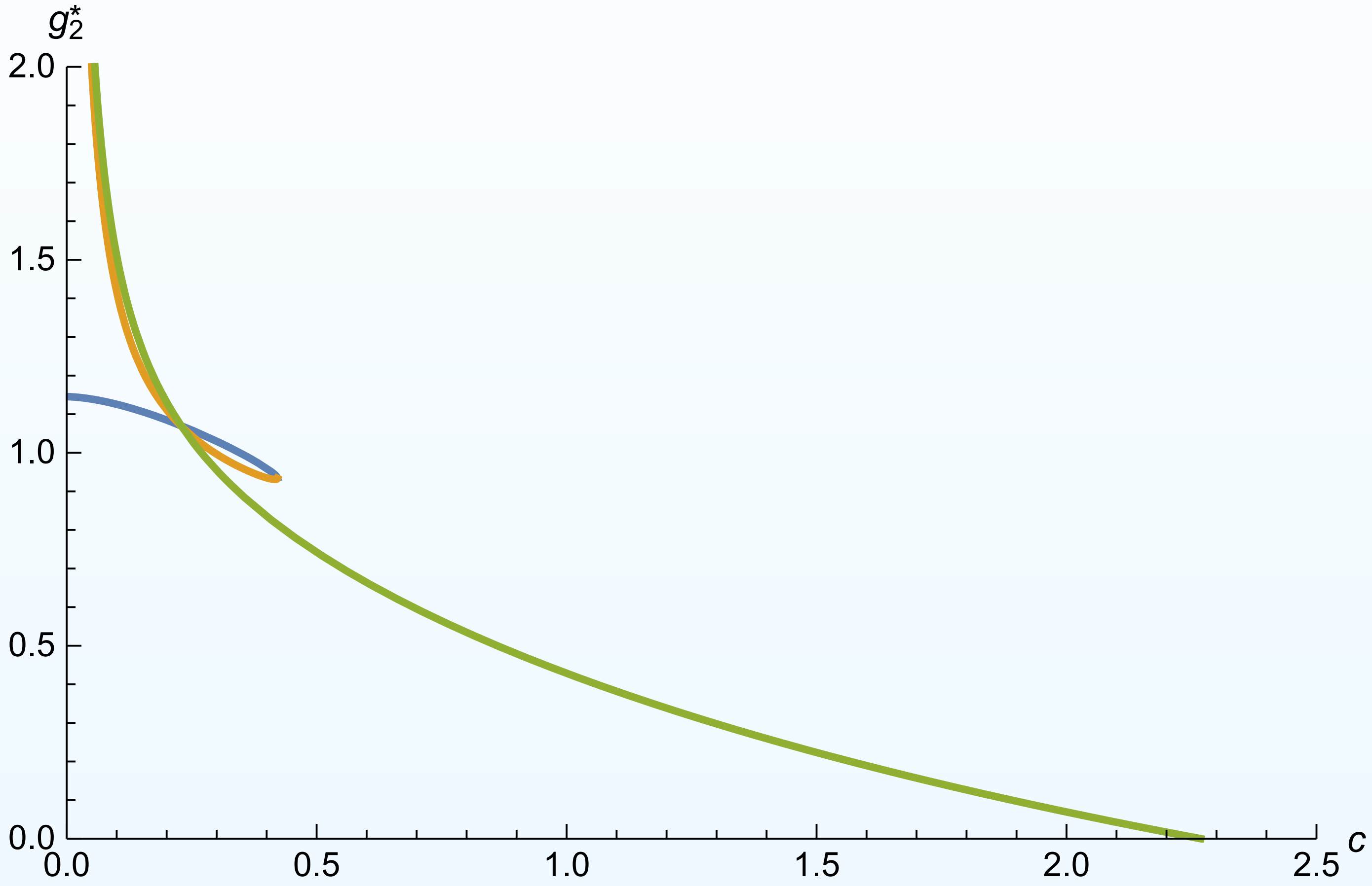
Type I

$c = 1$

Type II

Deforming gravity-matter fixed points ($N = 2$)

gravity + standard model matter



$c = 0$

Type I

$c = 1$

Type II

solutions II

global solutions

constructing global solutions

strategy I:

[N. Ohta, R. Percacci, G.-P. Vacca, arXiv:1507.00968]

1) fix structure of fixed function

$$\varphi(r) = \frac{1}{(4\pi)^2} \left(g_*^0 + g_*^1 \, r + g_*^2 \, r^2 \right)$$

2) find endomorphism parameters and values for g^i

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strategy II:

[J. Dietz, T. Morris, arXiv:1211.0955]
[M. Demmel, F. Saueressig and O. Zanusso, arXiv:1504.07656]

1) fix endomorphism parameters
    - singularity counting

2) determine $\varphi(r)$ through numerical integration

gravity + standard model matter (exact polynomials)

impose that $\varphi(r)$ is a second order polynomial

$$\varphi(r) = \frac{1}{(4\pi)^2}\left(g_*^0 + g_*^1\, r + g_*^2\, r^2\right)$$

structure of partial differential equation

$$\frac{\mathcal{P}_{\rm num}(r; g_*^i; \alpha)}{\mathcal{P}_{\rm den}(r; g_*^i; \alpha)} = 0$$

- gravity: $\mathcal{P}_{\rm num}(r; g_*^i; \alpha)$ 6th order polynomial in r
- gravity + matter: $\mathcal{P}_{\rm num}(r; g_*^i; \alpha)$ 8th order polynomial in r

gravity + standard model matter (exact polynomials)

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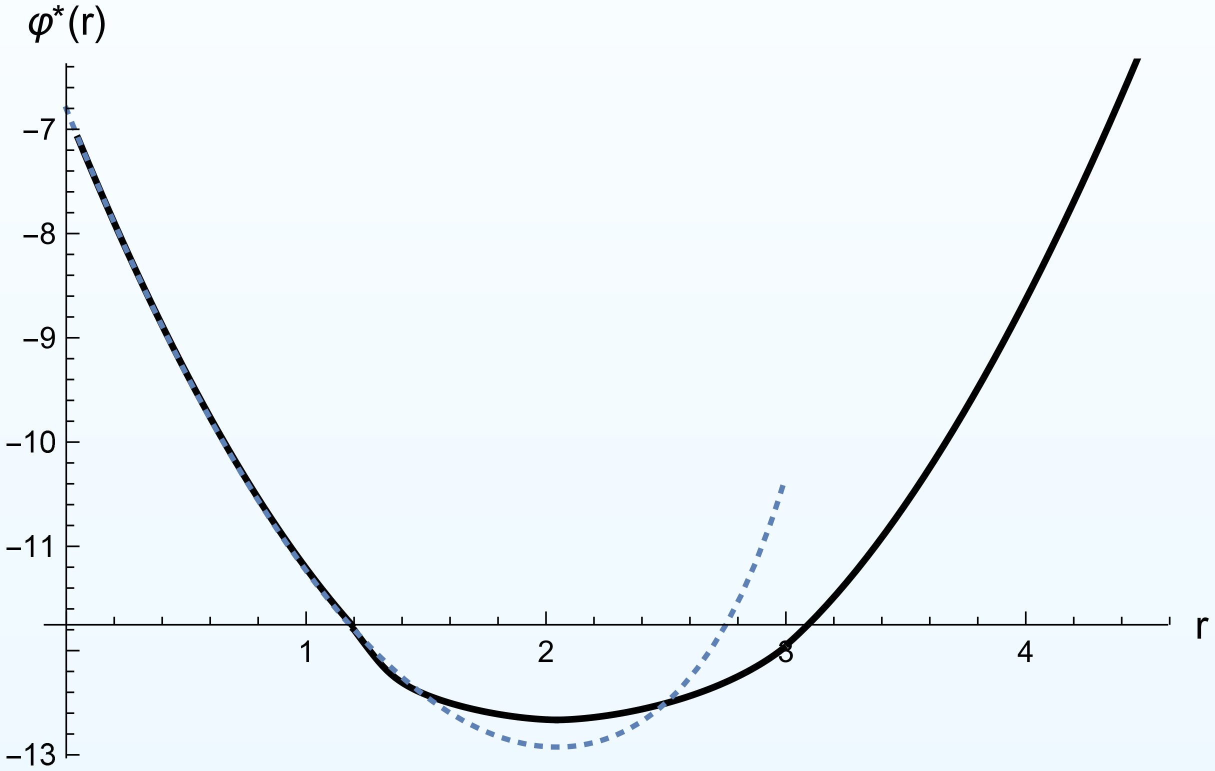
N_S, N_D, N_V	α_S^G	α_V^G	α_T^G	α_S^M	α_{V1}^M	g_*^0	g_*^1	g_*^2	r_{min}	Θ_0, Θ_1
(0,0,0)	0.04	0.32	-0.10	-	-	0.68	-1.18	0.45	1.31	4, 2.02
(4,45/2,12)	-0.02	0.16	-0.26	-0.09	-0.34	-6.70	-8.63	1.83	2.36	4, 2.36
(0,0,0)	-0.06	-0.15	-0.56	-	-	1.24	-1.07	0.21	2.51	$\approx$ 16, 4
(4,45/2,12)	-0.03	-0.11	-0.53	-0.36	-0.61	-5.81	-9.37	1.71	2.75	4, 2.8

gravity + standard model matter (numerical integration)

isolated solution by imposing regularity at

$$r^{\rm sing} = \frac{6}{5}\,, \qquad r^{\rm sing} = 3\,, \qquad \varphi'(r) = 0$$



gravity + standard model matter (numerical integration)

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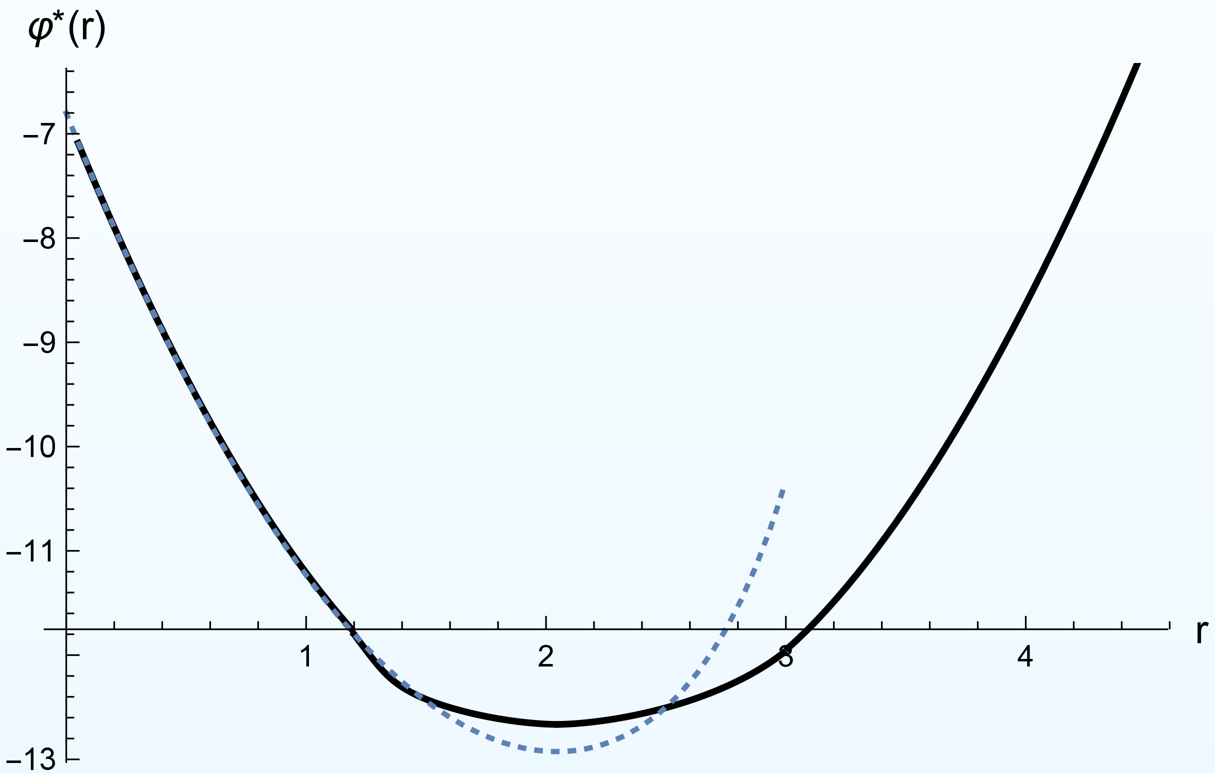

qualitative agreement with polynomial expansion

concluding remarks

summary . . .

fixed point structure: $f(R)$-gravity + matter:

- identified gravity-dominated NGFPs
  - $f(R)$-expansion converges
  - critical exponents resemble pure gravity
- identified “matter”-dominated NGFPs
  - $f(R)$-expansion has no convergence pattern

summary and open issues

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to be continued