Characterizing the Initial Stages of a Heavy-Ion Collision for Determining Final State Evolution: Including Conserved Charges, Momentum, and Stress

Jefferson Sousa and Matthew Luzum

Universidade de São Paulo

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Introduction

- Heavy-ion collision: complicated process represented as

$$V_n = \kappa_n \, \epsilon_n$$

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Final State

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Initial State

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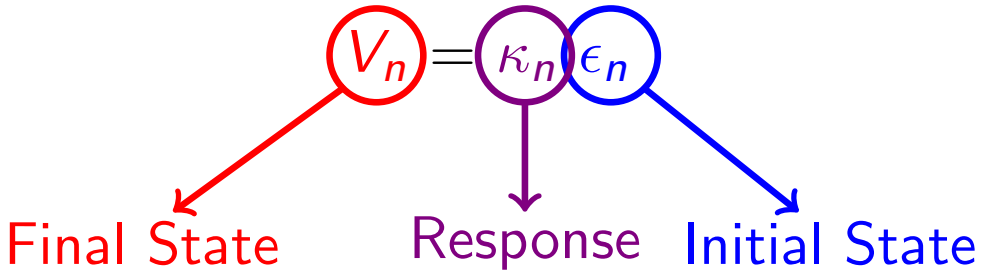

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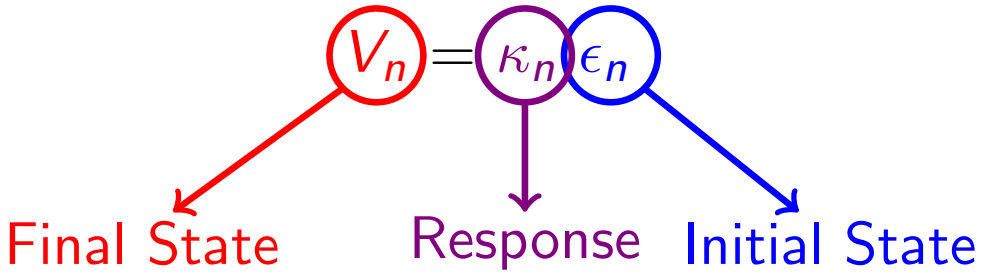

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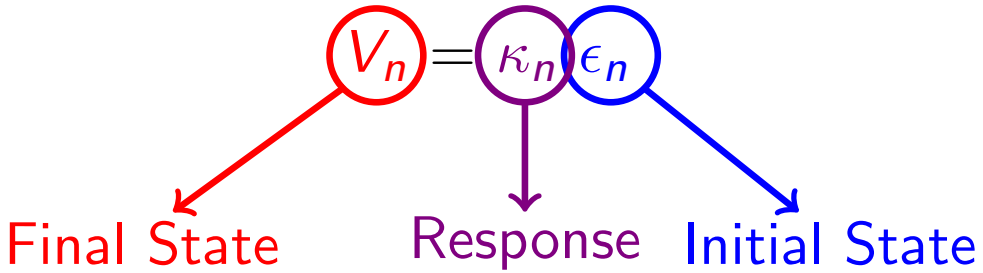

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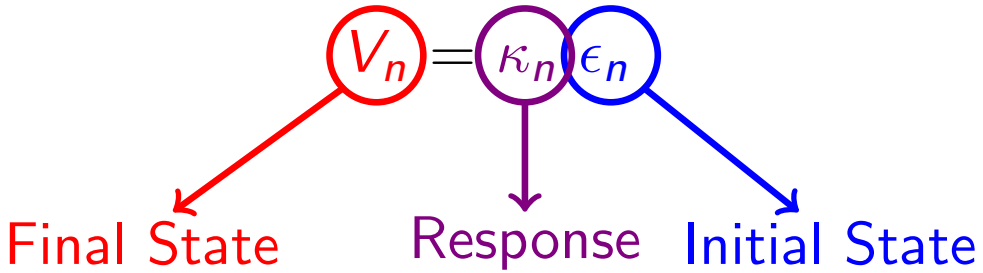

- Until now: only energy density is considered
- Goal: include $T^{\mu\nu}$ components and conserved currents
- Motivation: determine relevant aspects, importance of the contributions, importance in other collision systems

Cumulants expansion

Including Baryon density

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$$\boxed{V_n = \kappa_n \epsilon_n}$$

Cumulants expansion

Including Baryon density

$$\rho(\vec{x}) = T^{\tau\tau}(\vec{x}) + \gamma B(\vec{x})$$

$$\boxed{\epsilon_n(\gamma) = -\frac{W_{n,n}}{\left(W_{0,2}\right)^{\frac{n}{2}}}}$$

$$\boxed{V_n = \kappa_n \epsilon_n(\gamma)}$$

Cumulants expansion

Including Baryon density

- Charge conjugation

$$B(\vec{x}) \to -B(\vec{x})$$

$$V_n^{(net)} \equiv V_n^{+p} - V_n^{-p}$$

$$\overbrace{T^{\tau\tau}(\vec{x}) + \gamma B(\vec{x})}^{\rho(\vec{x})} \to T^{\tau\tau}(\vec{x}) - \gamma B(\vec{x})$$

- Antisymmetrizing the eccentricitry $\epsilon_n(\gamma)$

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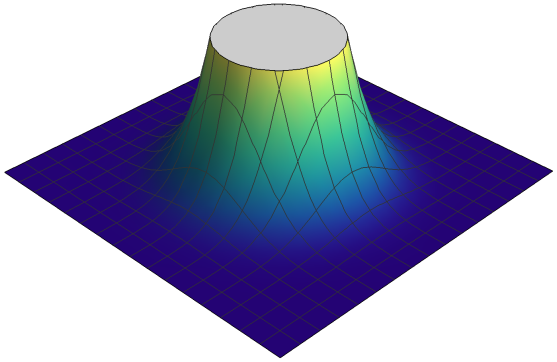
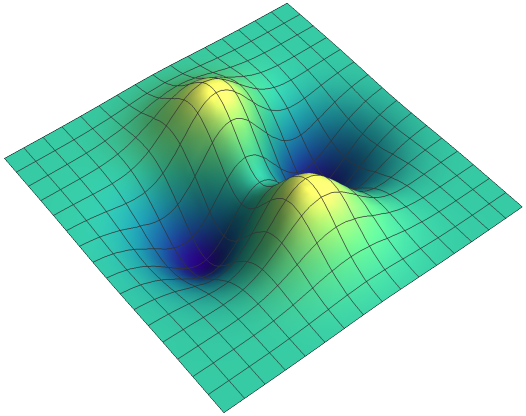
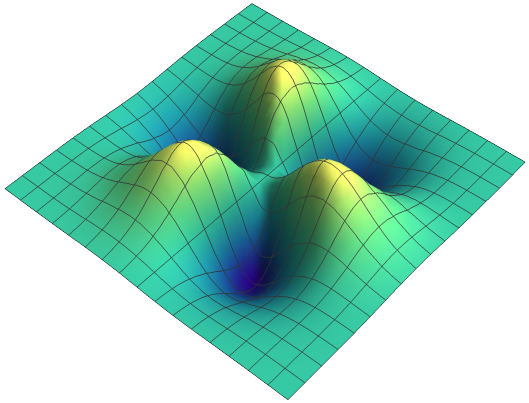
$$\boxed{V_n^{(net)} = \kappa_n \epsilon_n^{(net)}(\gamma)}$$

- Numerical tests



$$T^{\tau\tau}(\vec{x}) = Ae^{-\frac{r^2}{2\sigma^2}}$$





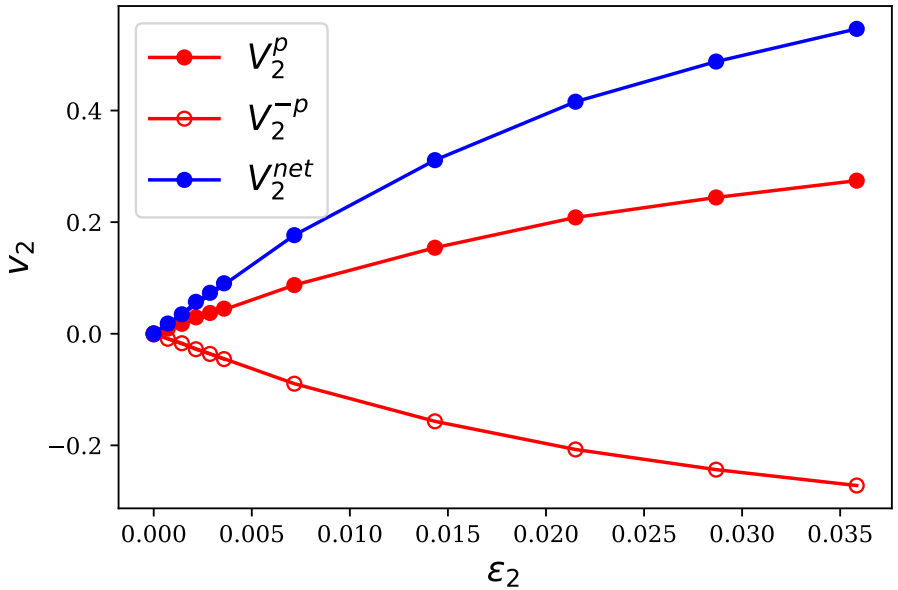
$$B(\vec{x}) = r^2 Re^{-\frac{r^2}{2\sigma^2}} \cos 2\phi$$

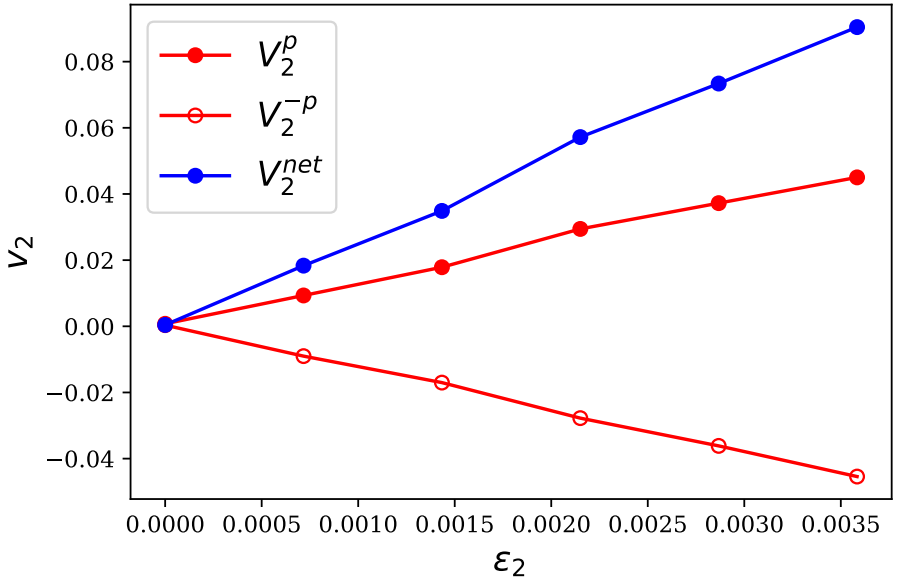
$$B(\vec{x}) = r^2 Re^{-\frac{r^2}{2\sigma^2}} \cos 3\phi$$

$$V_2^{net} = V_2^{+p} - V_2^{-p}$$

$$B(\vec{x}) = r^2 R e^{-\frac{r^2}{2\rho^2}} \cos 2\phi$$

R (fm^{-1})
$\{0.0 - 0.1\}$





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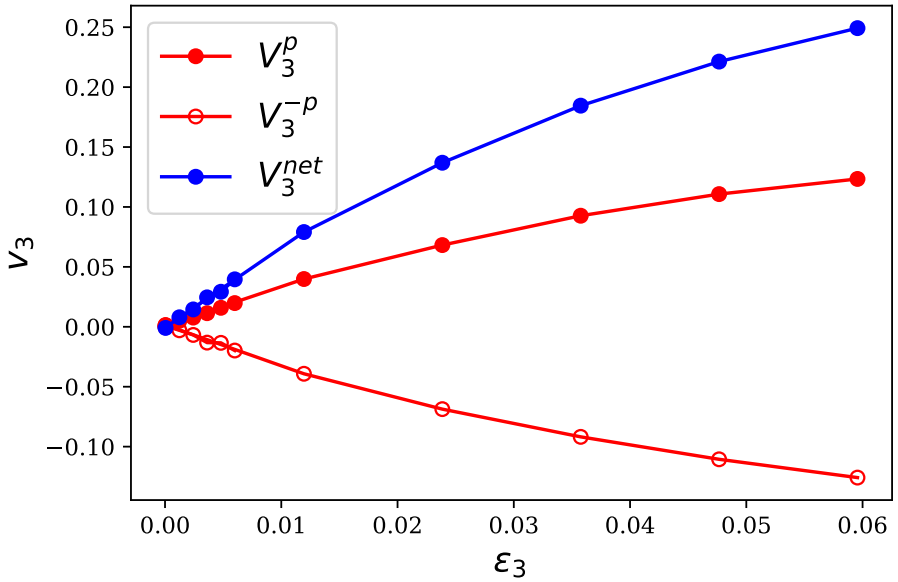

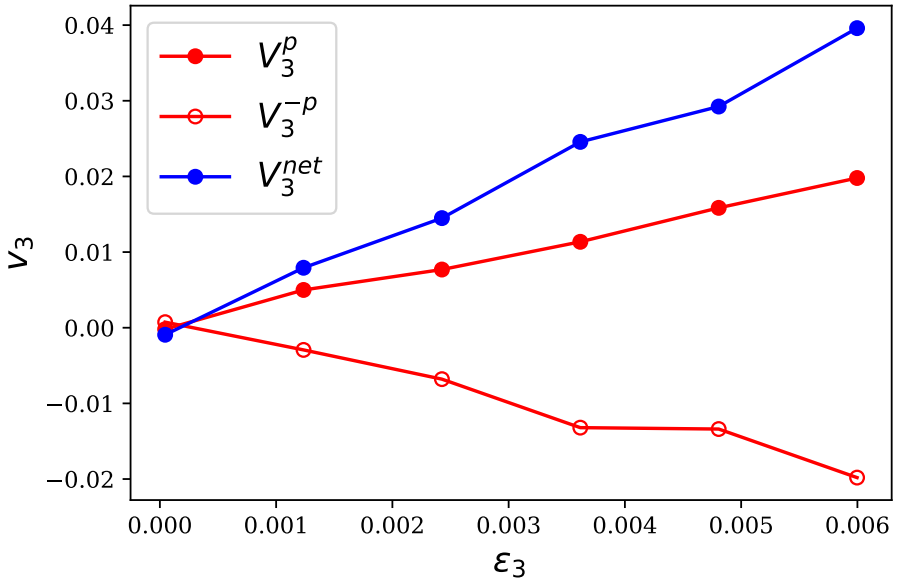

Conclusions

- Include other aspects of initial conditions in the eccentricity (ϵ_n)
- Numerical tests
- How treat the charge conjugation (Baryon density)

Extra: Cumulants expansion

$$\rho(\vec{x}) = T^{\tau\tau}(\vec{x})$$

$$e^{W(\vec{k})} = \int d^2x \rho(\vec{x}) e^{-i\vec{k}\cdot\vec{x}}$$

$$W(\vec{k}) = \sum_{n=-\infty}^{\infty} \sum_{m=|n|}^{\infty} W_{n,m} k^m e^{-in\phi_k}$$

$$\boxed{\epsilon_n = -\frac{W_{n,n}}{\left(W_{0,2}\right)^{\frac{n}{2}}}}$$

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Extra: Inlcuding Momentum and Stress

$$\rho(\vec{x}) = T^{\tau\tau}(\vec{x}) + \alpha\partial_i T^{\tau i}(\vec{x}) + \beta\partial_i\partial_j T^{ij}(\vec{x})$$

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$$\boxed{\epsilon_n(\alpha,\beta) = -\frac{W_{n,n}}{\left(W_{0,2}\right)^{\frac{n}{2}}}}$$

$$\boxed{V_n = \kappa_n\epsilon_n(\alpha,\beta)}$$