Edgeworth Streaming Model
for
redshift space distortions

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Correlation function

- measures excess probability

\[ 1 + \xi_X(s) = \left\langle (1 + \delta_X(s_1))(1 + \delta_X(s_2)) \right\rangle \]

- halos as biased DM tracers
  - input for halo model
  - powerful probe for cosmology

Redshift space distortions

- redshift observations affected by peculiar velocities

\[ 1 + \xi_X(r = |r|) \]

- isotropic

\[ s_{\parallel} = r_{\parallel} + v/H \quad s_{\perp} = r_{\perp} \]

- redshift space
  - anisotropic

Eisenstein et al.
Redshift space correlation function

Redshift space distortions

- observations in redshift space from galaxy surveys
- impact of peculiar velocities along line of sight

\[ s_{||} = r_{||} + v/\mathcal{H} \quad s_{\perp} = r_{\perp} \]

\[ r_{||} \quad r_{\perp} \]

real space

\[ s_{||} \quad s_{\perp} \]

redshift space

underdensity

linear evolution

overdensity

nonlinear structure

streaming model

\[ v \]

\[ \mathcal{H} \]
Gaussian Streaming Model

\[ 1 + \xi_x(s_{||}, s_{\perp}, t) = \int_{-\infty}^{\infty} \frac{dr_{||}}{\sqrt{2\pi}\sigma_{12}} (1 + \xi_x(r, t)) \exp \left[ -\frac{(s_{||} - r_{||} - v_{12}(r, t)r_{||}/r)^2}{2\sigma_{12}^2(r, r_{||}, t)} \right] \]

Streaming model

Edgeworth Streaming Model

\[ 1 + \xi_X(s_\parallel, s_\perp, t) = \int_{-\infty}^{\infty} \frac{dr_\parallel}{\sqrt{2\pi}\sigma_{12}} (1 + \xi_X(r, t)) \exp \left[ -\frac{(s_\parallel - r_\parallel - v_{12}(r, t)r_\parallel/r)^2}{2\sigma_{12}^2(r, r_\parallel, t)} \right] \]

\[ \times \left( 1 + \frac{\Lambda_{12}}{6\sigma_{12}^3} \left( \frac{\Delta_{srv}}{\sigma_{12}} \right)^3 - 3 \frac{\Delta_{srv}}{\sigma_{12}} \right) \]


- 2% down to 10 Mpc/h (ESM) vs. 30 Mpc/h (GSM)
Streaming model ingredients

Gaussian Streaming Model

\[
1 + \xi_X(s_\parallel, s_\perp, t) = \int_{-\infty}^{\infty} \frac{dr_\parallel}{\sqrt{2\pi}\sigma_{12}(r, r_\parallel, t)} (1 + \xi_X(r, t)) \exp \left[ -\frac{(s_\parallel - r_\parallel - v_{12}(r, t)r_\parallel/r)^2}{2\sigma_{12}^2(r, r_\parallel, t)} \right]
\]

Wang, Reid & White (2014, MNRAS 437)

Gaussian velocity distribution

mean pairwise velocity & dispersion

Lagrangian Perturbation Theory

+ local Lagrangian bias

- **Zel’dovich approximation**  
  - 1st order Lagrangian PT
  - physically motivated resummation of SPT

- **Post Zel’dovich approximation**  
  - higher order Lagrangian PT
  - partial resummation: Convolution LPT

Carlson et al. (2012, MNRAS 429)
Streaming model ingredients

**Gaussian Streaming Model**

\[
1 + \xi_X(s_{||}, s_\perp, t) = \int_{-\infty}^{\infty} \frac{dr_{||}}{\sqrt{2\pi} \sigma_{12}(r, r_{||}, t)} (1 + \xi_X(r, t)) \exp \left[ -\frac{(s_{||} - r_{||} - v_{12}(r, t)r_{||}/r)^2}{2\sigma_{12}^2(r, r_{||}, t)} \right]
\]

- **real space correlation**
- **Gaussian velocity distribution**
  - mean pairwise velocity & dispersion

Wang, Reid & White (2014, MNRAS 437)

**Lagrangian Perturbation Theory**

+ local Lagrangian bias

- **Why smoothing?**
  - implement halo size in fluid description
  - improves Zel’dovich predictions in N-body

- **truncated Zel’dovich**
  - Zel’dovich with smoothed input power spectrum
  - improves agreement with N-body


- **coarse-grained dust model**
  - CU & Kopp (PRD 91, 084010)
  - CU, Kopp & Haugg (arXiv: 1503.08837)

- **truncated CLPT**
  - Kopp, CU & Achitouov (in preparation)
Streaming model ingredients

**Truncated CLPT**

Kopp, CU & Achitouv (in preparation)

Real space halo correlation $\xi(r)$
- best agreement for 1 Mpc/h
- smoothing in $R(M)$ worse
  need to include peak bias
  Baldauf, Desjacques & Seljak (arXiv: 1405.5885)

**Pairwise velocity $v_{12}(r)$**
- best agreement for 1 Mpc/h
- smoothing in $R(M)$ slightly worse

**Pairwise velocity dispersion $\sigma_{12}(r)$**
- best agreement for $R(M)$
- consider cumulant not moment
Streaming model predictions

Redshift space correlation function

Kopp, CU & Achitouv (in preparation)

- plug streaming model ingredients in to obtain redshift space multipoles
  - monopole $\xi_0(s)$
  - quadrupole $\xi_2(s)$
  - hexadecapole $\xi_4(s)$

- TCLPT outperforms CLPT
  - simultaneously improves all higher redshift-space multipoles

- optimal: two-filter TCLPT smoothing
  - $\xi(r)$ & $v_{12}(r)$: 1 Mpc/h
  - $\sigma_{12}(r)$: Lagrangian scale $R(M)$

PRELIMINARY
Summary

**Edgeworth streaming model**
- generalization of Gaussian streaming model
- pushed 2% accuracy from 30 down to 10 Mpc/h


\[
\begin{align*}
\sum_{i=0}^{n} \frac{(-1)^i}{i! (n-i)!} \left( \frac{x}{n} \right)^i \\
\end{align*}
\]

**Truncated Zel’dovich approximation**
- truncated Post-Zel’dovich approximation (TCLPT)
  - optimal with two filters: 1 Mpc/h & R(M)
  - consistent results for \( \xi_0, \xi_2, \xi_4(s) \)

Kopp, CU & Achitouv (in preparation)
- peak bias effects relevant