第 29 卷 第 1 期
2011 年 1 月

天 文 学 进 展
PROGRESS IN ASTRONOMY

Vol.29, No. 1
Jan., 2011

博士论文摘要选登

三点相关统计的理论与测量

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摘 要：本文分别从数值模拟、理论和观测的角度研究和分析了三点相关函数以及双谱对尺度、形状和光度等的依赖性，并比较了数值模拟与二阶扰动理论以及暗晕模型的差别。我们发现二阶扰动理论即使在线性尺度上也是与数值模拟存在明显偏差的，它并不足以很好地描述暗物质双谱在大尺度上的行为。如果要与数值模拟更好地吻合，我们需要引入更高阶的修正。我们用其他人的半解析模型构建了对应于我们数值模拟的模拟星系样本，并计算了不同光度星系样本的双谱从而得到了相应的星系偏袒值。我们发现，对星系密度场的泰勒二阶展开是可以适用到准线性尺度 $k \simeq 0.15$ h/Mpc 上的，但是要通过三点相关来获得准确的星系偏袒值，我们需要拥有对暗物质密度场的准确估计，这却是二阶非线性扰动理论所无法做到的。暗晕模型在定性描述双谱行为方面是十分有效的，但是它与数值模拟的定量比较还是存在很多不同。要用暗晕模型来精确描述双谱，我们需要对模型的各种设定做出精细的调节和改进。最后，我们还利用了 SDSS 的最新观测数据测量了红移空间的三点相关函数以及投影三点相关函数，并研究它们对于星系光度、颜色和恒星质量等性质的依赖关系。我们发现，不同于之前的许多工作，星系的归约三点相关函数对光度存在明显的依赖性，而这种依赖性却是与三角形的形状和尺度耦合在一起。三点相关对恒星质量的依赖与光度依赖性十分类似。而颜色的依赖性在小尺度上则比光度和恒星质量更显著一些。

The Theory and Measurement of the Three-point Statistics

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Abstract: We use N-body simulations, theoretical models and also observational data to study and analyze the three-point correlation function, bispectrum and their dependence on

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scale, shape and luminosity. We compare the simulations with the second-order perturbation theory and halo models. We find that the second-order perturbation theory is not accurate enough even on very large scales to describe the behavior of the dark matter bispectrum. If we want to fit with the simulations better, we need to incorporate even higher order corrections, such as the one-loop correction. We construct the mock galaxy catalogs of our simulations based on others' semi-analytical models and calculate the bispectra and galaxy bias factors of different luminosity samples. We find that the Taylor expansion of the galaxy density field can be applied to quasi-linear scale of $k \sim 0.15$ h/Mpc. But accurate determination of galaxy bias with the bispectrum method requires the precise estimates of the underlying dark matter bispectrum. We have also tried the halo model as an alternative method to describe the bispectra of dark matter and galaxies. The halo model can qualitatively interpret the properties of the bispectra of both dark matter and galaxies. But it's not good enough to quantitatively match with the simulations, for which purpose we may need to consider all the possible inaccuracies in the model configurations. Finally, we calculate the three-point correlation function(3PCF) and projected function with SDSS data to study their dependence on galaxy properties. We find that different to the previous findings, the reduced 3PCF of galaxies shows clear dependence on galaxy luminosity, but such dependence is also coupled with the scale and shape dependence. The stellar mass dependence is quite similar to that of the luminosity, but there also exists slight differences. The color dependence of 3PCF seems to be more significant than the luminosity and stellar mass dependence.