JDEMFoMSWG report

Albrecht et al. 2009

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Parameterize DE with $w(a) = w_0 + w_a (1 - a)$

The DETF figure of merit is defined as the reciprocal of the area of the error ellipse in the $w_0 - w_a$ plane that encloses the 95% C.L. contour. (We show in the Technical Appendix that the area enclosed in the $w_0 - w_a$ plane is the same as the area enclosed in the $w_f - w_a$ plane.)

The *figure of merit is a quantitative guide*; since the nature of dark energy is poorly understood, no single figure of merit is appropriate for every eventuality.
Goal: Quantitative measure of how well future experiments will do in constraining nature of dark energy

Consistent with cosmological constant or time evolution of $\rho_{DE}$?
Deviation from GR?

- Pick fiducial model: WMAP5 $\Lambda$CDM + GR
- Predict data model for pre-JDEM and JDEM experiments (systematic errors, priors, etc.)
- Predict how well JDEM will do (Fisher matrix), extract useful figures of merit from this
Cautions

Figures of Merit only as good as data model

• JDEM may start ~2016, difficult to predict knowledge of DE, experimental systematics
• Need fiducial cosmology, priors
• Minor variations in assumptions can cause 10-20% changes in FoM
• No single number can describe scientific reach of JDEM
• Important criteria like systematic errors not captured
How to parameterize $w$?

• Many (physically motivated?) parameterizations possible, many with $\geq 4$ parameters

• Linder + coauthors (2005, 2006, 2007ab, 2008ab): *realistically only 2 parameters constrained*
  
  \[ w(a) = w_0 + w_a (1 - a) \]

• Albrecht & Bernstein 2006: 9 dimensional PCA of stage 4 (JDEM) experiments
  
  *best experiments constrain significantly more than 2 dimensions, impact substantially beyond DEFT analysis*
FoMSWG parameterization

- $w(a)$ described by 36 piecewise constant values $w_i$ in bins between $a = 1$ and $a = 0.1$
  - If it’s not $\Lambda$, don’t know what to look for..
  - can capture more complicated behavior
  - merit based on detecting $w \neq -1$ (any $w_i \neq -1$)
- Growth of Structure = Growth of Structure (GR)
  + $\Delta \gamma \ln \Omega_M(z)$
Figures of Merit

• Assume growth described by GR
  (but see Huterer & Linder for degeneracies..)
• Marginalize over all cosmological parameters except $w_i$

• Old (DEFT): Assume $w(a) = w_0 + w_a (1 - a)$
  parameterization, calculate DEFT FoM $(\sigma(w_p)\sigma(w_a))^{-1}$
• New plots: Principal component analysis of $w(a)$

• Additional number : $\sigma(\Delta \gamma)$
Figures of Merit: PCA Basics

- Errors in $w_i$ are correlated
- Expand $w(a)$ in a set of orthogonal eigenvectors (PC) $e_i(a)$
- 
  $$1 + w(a) = \sum_{i=1}^{36} \alpha_i e_i(a)$$
- $\sigma^2(\alpha_i)$ uncorrelated, use to rank order principle components
- Do this for techniques individually & in combination
Figures of Merit: PCA

- Sensitivity of PCs to $w \neq -1$
- Normalized to pre-JDEM, to quantify improvement by JDEM
- Expect significant improvement by JDEM for first $\sim 10$ eigenvectors

But difficult to relate to physics (e.g. De Putter & Linder 2008)
Figures of Merit: PCA

- Idea: First few eigenvectors indicate redshift at which experiment is sensitive to variations in DE density

But
EOS constraints from sum of all PCs

Assumptions on high z w shift peaks

Is highest best?