

# Posudek práce

předložené na Matematicko-fyzikální fakultě  
Univerzity Karlovy v Praze

- posudek vedoucího       posudek oponenta  
 bakalářské práce       diplomové práce

Autor/ka: Bc. Michal Vraštil  
Název práce: Determination of parameters of dark energy and modified gravity in the LSST project  
Studijní program a obor: Fyzika, Teoretická fyzika  
Rok odevzdání: 2015

Jméno a tituly vedoucího/oponenta: Mgr. David Heyrovský, PhD  
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## Odborná úroveň práce:

- vynikající  velmi dobrá  průměrná  podprůměrná  nevyhovující

## Věcné chyby:

- téměř žádné  vzhledem k rozsahu přiměřený počet  méně podstatné četné  závažné

## Výsledky:

- originální  původní i převzaté  netriviální kompilace  citované z literatury  opsané

## Rozsah práce:

- veliký  standardní  dostatečný  nedostatečný

## Grafická, jazyková a formální úroveň:

- vynikající  velmi dobrá  průměrná  podprůměrná  nevyhovující

## Tiskové chyby:

- téměř žádné  vzhledem k rozsahu a tématu přiměřený počet  četné

## Celková úroveň práce:

- vynikající  velmi dobrá  průměrná  podprůměrná  nevyhovující

## **Slovní vyjádření, komentáře a připomínky vedoucího/oponenta:**

The presented thesis explores models of dark energy in alternative theories of gravity. Primary emphasis is placed on chameleon gravity and its potential signatures on observations by the Large Synoptic Survey Telescope (LSST). This theory invokes a peculiar trick to avoid fifth-force constraints from Solar-system tests. The mass of the scalar particle of the hypothetical chameleon field depends on the surrounding density: in high-density regions its mass is large, implying a short-range force; in low-density regions its low mass permits kiloparsec-scale interactions.

The three main chapters are: chapter 2 with a detailed description of the LSST and Euclid projects currently under development; chapter 3 with an overview of dark energy treatment in a range of modified theories of gravity; chapter 4 with original results of numerical solutions for the chameleon field in simple toy models of a star and a galactic dark matter halo, plus a description of attempts to compute the chameleon field in a cosmological N-body simulation.

The model choice is unusual, since the primary relevance of the chameleon field is away from high-density regions, where it can mimic the effect of the cosmological constant. Nevertheless, it is a good idea to check if the chameleon field doesn't interfere at these scales. In this context one should point out that for a galactic halo with a 10 kpc scale it does not make much sense to plot the rotation curve out to 300 kpc. Regarding the cosmological simulations, attempts to jointly solve a gravitational N-body code with the Poisson-like chameleon equation do not look very promising. It might be better to use a gravitational hydrodynamic code, which solves similar types of PDEs.

Specific comments on the scientific content: the cosmological-constant term is a natural part of the general form of Einstein's equations, not a random ad-hoc term; most "problems" with Lambda are connected with its interpretation as vacuum energy density, they do not occur in its interpretation simply as a fundamental constant; the work could have included the observationally most relevant result: the cosmological evolution of the equation of state  $w(a)$  predicted by the different modified theories; weak lensing can be analyzed for rich galaxy clusters rather than for single galaxies.

Thesis structure: the bulk of the chapter on LSST (with near-verbatim passages from the LSST Science Book) is not very relevant to the main parts of the thesis. A watered-down version of the relevant aspects could be included in a general introduction or as a final chapter. On the other hand, what is missing is an initial overview of the standard Lambda CDM model, its successes and outstanding issues (especially since the thesis focuses on developments "beyond" Lambda CDM). Including printouts of the codes is pure dendricide (having them on the CD-ROM is sufficient).

Formal aspects: unexplained quantities in equations (e.g., 2.2, 3.19-3.21, 3.36, 4.48, etc.); citations by number are less convenient than author and year; references require more than just preprint number!

The advanced topic of the thesis and its ambitious scope resulted in the review part of the work overshadowing the more modest original contribution. Nevertheless, taking into account the lack of available experts in the field, the author's efforts are worthy despite the mentioned shortcomings.

## **Případné otázky při obhajobě a náměty do diskuze:**

Fig. 4.7 shows the varying spatial dependence of chameleon mass for a NFW halo, while the accompanying text in 4.5 states the spatial dependence can be neglected. Why?

**Práci** doporučuji nedoporučuji

uznat jako diplomovou/bakalářskou.

**Navrhuji hodnocení stupněm:** výborně  velmi dobře  dobře  neprospěl/a

Místo, datum a podpis vedoucího/oponenta:

Praha, 16. 8. 2015

David Heyrovský