Design of questionnaire to investigate students' conceptions about Cosmology and Universe

Arturo COLANTONIO, Silvia GALANO, Irene Marzoli

School of Science and Technology, University of Camerino, Camerino, Italy

Emanuella PUDDU

INAF – Osservatorio Astronomico di Capodimonte, Via Moiarello, 80138, Napoli

Italo TESTA

Department of Physics "E. Pancini", Complesso M.S.Angelo, Via Cintia, 80126 Napoli, Italy

Abstract. We present the design of a questionnaire to assess students' conceptions about Cosmology and Universe. To this aim, we first developed a 20-question open questionnaire. The content validity of the questions was checked with two professional astrophysicists. The open questionnaire has been submitted to about 60 high school students (17-18 years old). Reliability was investigated through inter-rater agreement. The analysis is in progress and the main results will be presented at the conference.

1 Introduction and aims

Recent curriculum reforms in Italy have promoted the introduction at secondary school level of up-to-date physics topics, as quantum mechanics, particles' standard model, the origin of the Universe and Cosmology. However, the implementation of such reforms has proven difficult, since such advanced topics require a deep understanding of underlying physics mechanism. As part of our ongoing research about the development of teaching-learning sequences (TLSs) [1] about astronomical phenomena [2-4], in this paper we focus on Cosmology and Universe as meaningful contexts to teach up-to-date physics topics as nuclear reactions, light spectra, redshift and dark matter. The main reason for choosing Universe and Cosmology as content area is that it is a motivating topic for students who chose physics at university level. Moreover, by exploiting these contexts, it is possible to teach relevant aspects of the Nature of Science and of Scientific Inquiry.

However, Cosmology and Universe is a content area where university students frequently hold a variety of alternative conceptions. For instance, previous research studies indicate that many students (about 70%) are unaware that the universe is expanding [5-7] and think that matter as we know it existed also before the Big Bang [6]. In some cases, students struggle to read and interpret the Hertzsprung-Russell and Hubble's plots or confuse the definitions of galaxy and solar system [8-9]. While valuable, however, the above results have been obtained through general astronomy surveys not specifically focused on students' conceptions about Universe and Cosmology.

Our main aim is to develop a new instrument to assess students' conceptions about Universe and Cosmology. This study is therefore guided by the following research question: *What is students' pre-instructional knowledge about Universe and Cosmology?*

2 Methods

To answer the research question, on the basis of previous studies, we have developed a first draft of the questionnaire in open form. Twenty questions were designed to target the following six key ideas in cosmology [9]: 1) Big Bang theory; 2) evolution, expansion and age of the Universe; 3) composition of the Universe; 4) time and distance scales for the Universe; 5) stars and galaxies; 6) dark energy and matter.

Example questions are: *Do you know what we mean by Big Bang? How would you describe in words and with a drawing the Big Bang? What do we mean when we say that the Universe is expanding? How do you think the chemical composition of the Universe has changed over time? Explain with words and a drawing what we mean by "expanding" Universe?*
The content validity of the questions was checked with two professional astrophysicists. We piloted the questionnaire with about 60 students (17-19 years) of high school following extra-curricular activities at our department about advanced physics topics. To score students' answers, using a grounded approach, we developed an initial rating rubric with three level: correct answer; partial answer; incorrect answer. We then investigated reliability of the findings through inter-rater agreement.

3 Conclusion and implication

Analysis of the students' answers is in progress and results will be presented at the conference. Emblematic students' answers will be used to design suitable answer choices for a multiple-choice instrument that will be submitted in different forms to a larger sample including students of different age and instruction levels. The students' answers to the multiple-choice questionnaire will be analyzed using Rasch analysis to establish whether the hypothesized key ideas form a coherent set of constructs that coherently describe students' understanding of Universe and Cosmology. Results will also inform the teaching at undergraduate level and the development of suitable research-based TLSs at secondary school level about the addressed topics.

4 References

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