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Swedish Upper Secondary Students' Views of the Origin and Development of the Universe

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Abstract. The article is addressing how students reason about the origin and development of the universe. Students' own views as well as their descriptions of physical models are analysed. Data consists of written surveys, and interviews of a subset of the students. Most of the students relate to the Big Bang model when describing the origin of the universe. The study however shows that this can mean different things to the students. The article also addresses views of whether or not the universe changes and of the origin of the elements. When comparing students' own views with their views of the physics view this study shows that there are students who have a different view of their own than the view they connect with physics. This shows that students, in the area of cosmology, do not necessarily take the view they connect with physics to be their own. Examples of students who handle the physics view in different ways are discussed. There are students who relate not only to science but also to a religious worldview when describing their own view. This shows that when discussing cosmology in class, also a religious worldview can be relevant for parts of the student group.

Key Words: cosmology, cross-cultural learning, physics, religion, upper secondary students, worldview

This study is part of a larger project addressing how upper-secondary students handle different contributions to their worldviews and how they relate these different contributions to one another. From our experience, in teaching physics, we know that many students are very interested when you in class come to discuss questions that have a clear connection to our worldviews. It is necessary to realise that science education is not only a matter of understanding specific science concepts. Lemke (2001) writes:

> It is not simply about what is right or what is true in the narrow rationalist sense; it is always also about who we are, about who we like, about who treats us with respect, about how we feel about ourselves and others. (p. 301).

Brickhouse (2001) argues in the same direction when she says that learning science cannot be viewed only as an acquisition of single concepts and under-

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standing of single phenomena but should also be viewed as a process of shaping identities. She writes:

> in order to understand learning in science, we need to know much more than whether students have acquired particular scientific understandings. We need to know how students engage in science and how this is related to who they are and who they want to be. (p. 286).

This is supported by some of the statements made by students in this study, that relate to the identity as a scientist or a science student:

> as a science student I believe in the Big Bang [Albert]

> There are however religious persons in class and because they don't believe in Darwin's theories about humans descending from the monkeys I don't really understand why they chose science at all [Lars].

A worldview can be viewed as an aspect of culture and is an aspect that is highly relevant for science education. Most people do not have physics or science as their only influence on areas bordering existential questions, but are also influenced by religious or metaphysical views (Cobern, 1996; Helve, 1991). Cobern & Aikenhead (1998) describe students' meetings with science education as a meeting between two cultures, namely the culture of science (education) and the students' own culture. This new culture can be more or less in harmony with the students' own cultures, and because of this the education can be either "supportive or disruptive" (Cobern & Aikenhead, 1998, p. 41):

> "If the subculture of science generally harmonizes with a student's life-world culture, science instruction will tend to support the student's view of the world ('enculturation'). On the other hand, if the subculture of science is generally at odds with a student's life-world culture, science instruction will tend to disrupt the student's view of the world by trying to replace it or marginalize it ('assimilation')." (Aikenhead, 1996, p. 5).

Aikenhead (1996) argues for science to be taught in a cross-cultural way. For students for whom the science culture is not supportive there will then be alternative ways to learn science, namely autonomous acculturation and anthropological learning. Autonomous acculturation is:

> "a process of intercultural borrowing or adaptation in which one is free to borrow or adapt attractive content or aspects of another culture." (Aikenhead, 1996, p. 26).

While autonomous acculturation means that the student adopts parts of the scientific view and combines it with his or her other views, anthropological learning means that the student learns about the scientific view without taking it to be his or her own view:

> "Anthropological' learning is associated with students who enjoy and are capable of constructing meaning out of the 'foreign' subculture of science, but who do not assimilate or acculturate science's cultural baggage." (Cobern & Aikenhead, 1998, p. 43).

Cultural meetings can be studied by interviewing teachers and students about their views and comparing these views to one another (Cobern & Aikenhead, 1998). Here we use a different strategy. We let the students themselves tell us about how they view the physics view of different questions. We are in this way following Marton and Booth (1997) when they are arguing that the world that exists to humans is the experienced world. When the students decide whether or not science culture is a culture they want to be part of, the decision is built on students' own views about the culture and what it stands for, not the teachers' or researchers' views about the same thing.

In the overall project, of which this study is the first part, we are studying how students handle different contributions to their worldviews, how they relate them to each other, and how this can be used to improve science teaching. We especially focus upon the relationship between science and religion. Students' views of this relationship have been reported earlier in some studies (Dagher & BouJaude, 1997; Fysh & Lucas, 1998; Roth & Alexander, 1997; Shipman, Brickhouse, Dagher, & Letts, 2002). This article builds on an explorative study of how Swedish upper-secondary students reason within a specific content area, i.e., the origin and development of the universe. The area is chosen because of its close relation to existential questions. There is only a limited amount of reports on students' ways of discussing the overall universe, e.g., Lemmer, Lemmer, & Smit (2003), Shipman et al. (2002) and Spiliotopoulou & Ioannidis (1996). The student sample in this study differs from earlier studies, referred above, since the students come from ordinary public upper-secondary schools in Sweden, a country often described as highly secularised. We also focus upon students' descriptions of the scientific views in the area, in order to address questions related to whether students want to make views of the scientific culture their own or not. The research questions this study is designed to address are:

1. How do upper secondary students describe the physics view[1] and their own view of the origin and development of the universe?
2. How do students handle their views of the scientific models, related to the area in focus, when describing their own view?
3. To what extent and how is a religious worldview relevant for the students when discussing the origin and development of the universe?

Subjects and Methods

The students in the study are in the last year of upper-secondary school (normally 18–19 years old). In Swedish upper-secondary schools the students choose between different national programs (there are also local variations offered). The students in this study are attending the natural science program. Within a specific program, the students have to choose among different courses. All of the students in this study

have chosen to take the most advanced regular physics course. In this course the overall development of the universe is part of the syllabus, but is usually treated very briefly. The programs in Sweden are, however, rather broad and the natural science program includes much more than science. Thus areas covered in this study might have been discussed in other courses as well. For example all students take a course in religious studies, and some of them take optional courses in philosophy. One of the schools has locally specific courses, that some of the students take, including among other things, an orientation of science history, science methodology and scientific research.

Eighty-eight students participated in answering a written survey (26 students in the pilot phase and 62 in a slightly modified survey). The students are from three schools (and five groups) in different towns. The small modifications made after the pilot phase have not changed any important aspects of the questionnaire for this paper, and we use answers from all 88 students in the analysis. Twelve of the students were interviewed. The interviews were semi-structured and dealt with the same issues as the written survey, sometimes other issues were discussed as well. The interviewees were chosen from two of the three schools, among the students there who were willing to participate. Among those, we chose students who had expressed different views when answering the survey. In this way we were trying to maximise the variation of different views (Marton & Booth, 1997) that we were able to get a deeper understanding of. The interviews also make it possible for us to get a better understanding of the overall reasoning of an individual student.

The written survey consisted of nine different questions. The three questions that this paper builds on (see Appendix A) probe students' views of phenomena that are connected to cosmological theories, scientifically described by the Big Bang model. We asked them to describe the physics as well as their own view of:

- whether the universe has an origin or whether it has always existed [Q1[2]]
- whether the universe changes or whether it is unchangeable [Q2]
- when elements necessary for life on the earth came to be (these elements were exemplified in the question by carbon, oxygen and nitrogen) [Q5]

Students' answers to other questions have been taken into consideration as well, when they have concerned the focus of this report. The design is open for the possibility that students could have a different view of their own than the view that they connect with physics. This makes it possible to follow how they use their view of the physics view when describing their own view.

Because of the limited amount of research in the area of students' views related to cosmology we chose to have these questions open-ended so that the students themselves could formulate their answers. Hence we have, through an iterative interpretative analysis, constructed category systems that describe the different

views found in the data. This has been done through both of us reading the written answers and interview transcripts repeatedly extracting the different views that are present in the group. The different categories are exemplified with statements to clarify the view that the category describes. There are several vague statements that have been hard to categorise. The amount of students with statements in the different categories should therefore be understood as an approximate number and are presented in the article to give an idea of how common the different views are in the studied group.

When presenting the results we start by presenting the different views of the universe that are present among the students. This includes students' own views as well as their views of the physics view (research question 1). We end with individual examples of how the students' own stated view is related to the view that they describe as the view of physics (research question 2 and 3). Examples from students for whom the views are the same and for whom there are differences will be given.

Results and Discussion – Views of the Universe

Overview of the Views of the Universe

Most of the students (85 out of 88) at some point in the survey refer to the Big Bang model, explicitly or implicitly (for example through describing an explosion or an expansion from something small). The students have obviously heard about it, and in some way they connect it with the universe. Most of the students connect the Big Bang with something happening to the whole of the universe. This can however mean very different things and it is obvious from this study that even though most of the students refer to the Big Bang model they have different views of the origin and development of the universe, both for their own views and for their views of the physics view. Thus, referring to the Big Bang model does not necessarily imply that the students' view is that it has been an absolute origin of the universe, and that the universe has expanded from one point. For example, there are students saying that the universe has always existed in some way. Others talk about a beginning with the Big Bang, but show that they do not view this as an absolute beginning of the universe. Because of this the Big Bang should in this article be interpreted more widely than as an absolute origin of the universe. It could also mean a transformation of the whole universe. In addition to the view described above where the Big Bang is viewed as something happening to the whole of universe, there are also some students who talk about the Big Bang as the origin of the earth and/or the sun.

Table 1 shows the different views that have been found in the data, concerning the four aspects addressed in this article. These are illuminated by examples of

Table 1
Views Concerning the Origin and Development of the Universe Found in the Data (Valid Both for the Students' Own Views and Their Views of the Physics View).

A. Whether or not there has been an absolute beginning of the universe	B. The former extension of the universe	C. The origin of the elements	D. Whether or not the universe expands today
A1. The universe has an absolute beginning – */.../ I believe in the Big Bang and that before that there was nothing. Time and matter came to be at this time/.../* [Urban, own view, Q1]	B1. The universe was once point-like (very small) – *You assume that the Big Bang was there, that it happened. It's the earliest that I have heard from physics. That is, you believe that all matter in the universe was in this point, and that it spread out with the explosion./.../* [Max, physics view, Q1]	C1. The elements has always existed or did exist before the Big Bang – *The elements were in the big clouds of gas that collided during the Big Bang. After the collision they were spread out and could be attracted by each other* [Ella, own view, Q5]	D1. The universe is expanding/growing – *The universe lives its own little life just like us humans on earth. Stars go out, stones fly around. Stars collide. The universe becomes larger & larger all the time* [Erika, own view, Q2]
A2. The universe has a beginning, but something existed before	B2. The universe was once contracted, but still rather large	C2. The elements came to be in the Big Bang/when the universe was created or closely after that	D2. The universe is not expanding/growing

Table 1 *continued*.

– The physics view is, I think, that it all began with 'Big Bang' and that 'big bang' came from a number of clouds of gas that were gathered and pressed together. /.../ [Sten, physics view, Q1]	*– /.../ The physics view is that the universe arise by the 'Big Bang.' It was a burning ball of gas or something that burst and formed the universe. I don't remember exactly how it happened* [Felicia, physics view, Q1]	*– They came to be during the Big Bang* [Jane, own view, Q5]	(See Adam's story later in the article.)
A3. The universe has always existed	B3. The universe has not been contracted	C3. The elements came to be much later in the history of the universe/long after the origin of the universe/long after the Big Bang	
– I believe that the universe has always existed, but that there haven't been for example bodies/future planets. I still believe that a Big Bang caused the planets to be & the universe to look the way it does today [Jan, own view, Q1]	*– /.../I have difficulties imagining that the universe just came to be. But at the same time I don't think that it has always existed. I believe that the universe came to be accidentally. It was two substances that crashed into one another & a big explosion took place*. [Erika, own view, Q1]	*– I think that the elements on earth were formed when the earth came to be because some elements here are unique to our planet while other planets surely have elements that are not here. If the universe was created by God he might have given us what we need to live.* [Frida, own view, Q5]	

students' statements. The categories however capture a range of different views. Some of the statements given as examples refer to students' own views while some of them refer to their views of the physics view. It has not been possible to find any overall views, or patterns of views concerning different aspects of the universe. This does not mean that the individual students are not making sense when describing their view of the universe. The combinations of views of the different aspects of the universe that are included in the students' worldviews, however, seem to be very individual.

Notice that the same views have been found in the students' descriptions of their own views and in their descriptions of the physics view. However the distribution of the different views concerning one aspect could very well differ between the students' own views and their views of the physics view. How common the different views are in students' descriptions of their own views as well as the physics view will be discussed below for aspect A, C and D. For aspect B we cannot say anything about this because this aspect has not been explicitly asked about in the written survey. Some of the students have in their answers given us information about their view of this anyway and the interviews have also given information about it. From this data we can tell about the different views present, but not present any frequencies.

The Frequencies of the Different Views

Whether or Not there has been an Absolute Beginning of the Universe

All the three different views (A1, A2 and A3) of the origin of the universe are present and rather common in the student group, both when the students describe there own view and when they describe the physics view (see Figure 2 in Appendix B). Most students describe some sort of beginning of the universe, especially when describing the physics view. The majority of these students however, do not talk about an absolute beginning (view A1). Instead many of them talk about a beginning, but at the same time they show that their view is that there has been some sort of pre-existing matter before the beginning of the universe (view A2). There are also many students who explicitly state that the universe has always existed (view A3). This is more common when the students describe their own view than when they describe their view of the physics view. For the view that the universe has an absolute beginning we have the opposite situation.

Views of the Origin of the Elements

Many of the students seem uncertain concerning the origin of the elements that are necessary for the life on earth (exemplified by carbon, oxygen and nitrogen in

the survey). Many of them do not answer the question and others state that they do not know (see Figure 3 in Appendix B). Even others do not give a clear answer to when the elements came to be, but are instead very unspecific in their statements. One reason for not dealing with the question can be that the students do not know very much about it. For some of them 'elements' does not seem to be a well understood concept. Another reason could be that the students seem not to have given the topic much thought. They do not seem as engaged in this question as in other questions, e.g. the question of the origin of the universe.

The most common view is that the elements were formed in the Big Bang, when the universe was created, or closely after that (see Figure 3, Appendix B). When describing their own views only four students express a view that the elements were created in the stars long after the Big Bang. These students state the same view when describing the physics view, so this view does not seem to be a view held without knowing about the scientific model. It is much less common, than in the case of the origin of the universe, that students describe different views when describing their own and the physics view, even though there are a few examples of this.

Students Views of Whether the Universe Changes or Not Today

None of the students describe a universe that does not change, neither when describing their own or the physics view. However, the students describe the changes in different ways. When describing the physics view many students write that the universe expands or grows, and/or give examples of things in the universe that change, e.g., that stars are born and/or die (see Table 2 in Appendix B). Some of the students write that the view of physics is that the universe changes, but are not explicit about what the change is about.

The interviews show that the expansion could be viewed in different ways where some students describe "a real" expansion, while others seem to view Big Bang as an explosion giving matter speed enough to move away from the centre.

Results and Discussion – How Individual Students' Views of the Universe are Related to Their Views of the Physics View and to a Religious Worldview

In this part we will first discuss, and show examples of the different ways to handle the physics view that are present in the data, and also discuss examples of students who in one way or another relates to a religious worldview when describing the origin of the universe. Finally we will discuss two students in more detail.

Different Ways to Handle the Physics View

Notable is that the students often refer to what they have stated to be the physics view when describing their own view. This can be done by mentioning the Big Bang model or by referring to what they have written about the physics view. However the relationship between the students own views and his or her view of the physics view differ between individuals.

Figure 1 shows how the students own views, concerning whether or not there is a beginning of the universe (aspect A in Table 1), are related to the view they have described as the physics view. Many students describe their own view in a similar way (same view from Table 1) compared to the view they have described as the view of physics, while other students (almost 25%) describe another view. There are also students who present, what we call, a more pronounced (less vague) position for one of the views, e.g. they change from *Beginning, but vague whether absolute* (A1/2) to *Beginning – from something* (A2).

The examples below of how these different relationships, between the descriptions of students' own views and their views of the physics view, manifest

		Physics view				
		A1	**A1/2***	**A2**	**A3**	**No answer**
Own view	**A1**	6	0	1	0	0
	A1/2*	0	21	4	1	1
	A2	2	3	17	0	0
	A3	4	9	4	11	1
	Do not know	1	2	0	0	0

Different view

More/less pronounced view

Equal/similar view

No answer/ do not know

Figure 1: How students' own views, concerning whether or not the universe has a beginning (aspect A in Table 1), are related to their views of the physics view.

*It is rather common in the written survey that the students describe a beginning of the universe, without being explicit about whether or not this beginning is an absolute one. These statements are categorised as *Beginning – vague whether absolute*. We do not think that there is another view "hidden" in the answers categorised as *Beginning but vague whether absolute* (A1/2). From the data we conclude that these students either do not know or have one of the views described above.

themselves in different students' statements are from students' statements concerning the origin of the universe – the aspect in Table 1 where it seems to be most common that the descriptions differ. However, there are individuals describing a view of their own that is different compared to their description of the physics view also concerning the other aspects. We will later in this article show how two students handle the physics view when formulating their own view concerning their views of all the aspects focused in this article. The stories of these two students will show that it is possible that an individual student concerning one aspect of the universe presents a view equal to the view of physics, while he or she presents different views for other aspects.

Students having an Equal or Similar View to the View they Describe as the Physics View

There are students in this study that explicitly state that they agree with the view of physics. There are also many students who describe their own view similarly to the way they have described the physics view, see Figure 1. One student that agrees completely with his view of the physics view of the origin of the universe describes his own view like this:

I agree with the physics view on this. It's the only realistic thing one has come up with [Klas, own view, Q1].

Even though many students agree with the physics view the statement below shows that this can be done out of 'necessity', i.e., he does not seem happy about it:

I would prefer that the Christians are right. That is, that God created the earth and that there is a life after this. But I don't believe that it's like that. I believe in the Big Bang and that before that there was nothing. Time and matter came to be at this time. As long as no one can prove something else I have to believe in this. It's not proven either, but it sounds most reasonable [Urban, own view, Q1].

These students seem to have taken the physics view as their own without modifications. The two students are either enculturated or assimilated (Aikenhead, 1996) into the scientific view of the origin of the universe. It is not possible to say for certain from this study which of these is the most relevant description, but the statement of Urban indicates that assimilation is the most relevant description for him.

Students who Describe Another View than the View they have Described as the Physics View

Most of the students, when describing their own view of the beginning of the universe, agree with the view they have described as the view of physics. However, there is a significant number of students who describe another or at least a modification of the view they have described as the physics view, see Figure 1.

This shows that it is not always that students take the physics view as granted for their worldview. There are students who believe in a universe without an absolute beginning even though they describe the physics view as a universe that has an absolute beginning. Roger describes the physics view of whether the universe has a beginning or not like this:

> It started with the big bang where an explosion made gases and particles spread out in space and then they attracted each other and formed suns [Roger, physics view, Q1].

Roger obviously knows about the Big Bang model and seems to understand that it implies a beginning of the universe. Nevertheless when describing his own view he states:

> It has always existed [Roger, own view, Q1].

This is an example of "comprehension does not necessitate apprehension" (Cobern 1996, p. 592), named anthropological learning by Aikenhead (1996).

There are also students who, when describing their own view, refer to the Big Bang model but describe it in a modified way compared to their description of the physics point of view. Filippa describes her view of the physics view like this:

> I would say that the view in physics is that there has been a huge bang "Big Bang" and that the universe after that has grown more and more, expanded, and that it will come together again one day [Filippa, physics view, Q1].

When describing her own view she refers to the Big Bang, but not really as a beginning:

> I believe like the physicists about this but I have a problem with a bang coming out of nothing. There must have been something before [Filippa, own view, Q1].

References to the Big Bang can be made in different ways. Some of the students describe the universe in a cyclical way where 'our' Big Bang is just one of many. Oliver describes his view like this:

> I believe there was something before the Big Bang, something like another universe. Because the universe expands and then (will) contract again I think that there just before the B.B. was an implosion of the previous universe [Oliver, own view, Q1].

However this is not the way he views the physics view of the universe:

> Big Bang, a lot of particles and a high energy, created the universe [Oliver, physics view, Q1].

We think that these two students try to integrate a view that the universe has existed forever with the scientific model of the universe starting with the Big Bang.

This can be thought of as an example of the autonomous acculturation put forward by Aikenhead (1996). Notice that there are advocators of a cyclical view of the universe also within the society of physicists.

Students who are Unsure About what to Believe

There are examples of students not being sure of their own view, but describing the physics view as either a universe with an absolute beginning or a universe that has always existed. This shows that students who hesitate in describing the physics view as their own do not necessarily have another strong view – at least not one they want to present.

Students who Relate to a Religious Worldview

It is rather common[3] that the students when discussing the origin of the universe relate also to a religious worldview. Some of these students are not sure about what to think, while others take a religious or non-religious position. This shows that there are other influences than science that are relevant for many of the students when discussing the universe. We will show some examples of students' statements about this. The statements are both from students taking a non-religious and a religious position.

Non-religious Positions

There are students who, like Eskil and William below, state a clear position that no god has something to do with the origin of the universe:

> It hasn't existed forever but has been created a long time ago. How I don't know, but I also know that god didn't create it./.../[Eskil, own view, Q1].

> like above [relates to the description of the physics view], (I'm a scientist, I'm not that religious) [William, own view, Q1].

The statement by William is an example of that for some of the students a non-religious position is connected to their identity as science students. Such a statement supports the importance of what Brickhouse (2001) and Lemke (2001) state about students' identities being closely linked to science education.

Religious Positions

There are students who believe in a god that created the universe that seem to think that it is important to state that this view is compatible with the scientific view. For example they state that their belief in a god does not exclude a belief in the

physical view. This is explained in different ways leaving more or less power to the god they believe in. Some of them, like Knut below, express a belief in a god that created the Big Bang:

I believe that it has not been there forever [the universe] but big bang or something like it I believe has happened. But thanks to my Christian belief I think that the power that started it all was God. Still I don't think it took seven days like we experience them but seven days for God. This time I believe is rather long about the same as the scientists have calculated. The order of things that the scientists believe that the universe has created is similar to the story of the creation in the bible [Knut, own view, Q1].

Another student, Ragnar, expresses his view like this:

What I believe is that the universe must have a beginning. That the universe has a beginning – you can show by studying the stars that it is expanding all the time; something that widens must have a beginning. Here I believe that God is the creator of all of it, which I want to show with the Koran, in which it, among other things, is written about how the earth came to be. That is Big Bang can also have happened! [Ragnar, own view, Q1].

This student seems to view the Koran as the primary source for his worldview but finds scientific models and discoveries compatible with this. This is obvious from his answers to the survey, where he mentions his faith in some way, in almost every answer. This particular student does not seem to view science to be in conflict with his religion. His religion influences also his answers to the physics view.

The two students, Knut and Ragnar, both could be said to practice autonomous acculturation when combining the Big Bang model with their view of the universe being created by God. There are also examples in the data of students believing in a god but not in a god that has created or influenced the overall development of the universe.

Two Students Ways to Handle Physics when Describing their Own Views of the Universe

We have chosen to describe two specific students – Adam and Lisa – in order to give a detailed description of their views of all the aspects focused in this article. The students are handling the physics view in rather different ways, and both of them describe their own view differently from their view of the physics view. One of the students, Lisa, relates not only to a scientific worldview but also to her religious belief, when describing her view of the universe.

Adam's Story About the Universe, the Physics and Himself:

Adam is very interested in the universe and says that he has read a lot about it. He also discusses questions concerning the universe with friends. Adam has his own

view of the universe that in some aspects differ from the view he describes as the physics view. He and his friends have discussed their own views about cosmology, and Adam has in the latest discussion argued for the kind of cyclical universe that he describes as his view of the universe in the survey and the interview.

Adam believes that the development of the universe is so complex that it is impossible to predict in total. He agrees with physics in that all matter has been in one place. How large this place was he does not know – it could be like a needle or like a ball of the size of the earth. He does not know if matter, according to physics, have been in that place forever, before the Big Bang, or not. After the Big Bang, about 10 billion years from now, matter was spread out, caused by the explosion. When matter looses its speed it stops, in different places. About the boundary of the universe Adam says:

Adam: /.../ as far as the matter was thrown out well that is how large the universe is
Interviewer: what about the boundary there?
Adam: I see it more as a sort of boundary there, that the matter ends.

Adam himself believes the universe to be cyclical and that the Big Bang is just one of many. A cyclical view of the universe seems to be a rather strong conviction:

Interviewer: But in this large-scale, that it will become larger and then smaller and then larger and smaller...
Adam: Yes
Interviewer: About this you feel rather
Adam: Yes
Interviewer: convinced?
Adam: Not very, I guess I'm not convinced but well that's what I believe.
Interviewer: Mm
Adam: That is my opinion...what I have thought during summer evenings when looking up.
Interviewer: Mm, but the physics view is more ...
Adam: It is one, and then it has exploded and then here we are where we are.
Interviewer: And it is more or less the same right now?
Adam: Yes
Interviewer: And it remains as it is?
Adam: Just about, yes.

Adam says that, according to physics, matter has now stopped – and the universe does not change its size anymore. From now on the universe will be pretty much like it is, concerning the size. This does not mean that he believes that the physics view is that the universe does not change at all – instead he states that the universe changes all the time, both according to physics and to himself:

stellar positions change, the structure of planets reform, stars explode and become supernovae [Adam, physics view, Q2].

Adam, himself, believes that the universe, for the moment, is just about to contract again. One possibility for him is that this happens through black holes, which he describes like this:

Adam: There might have been other big bangs that ...but we only know about one. That it is gathered, exploded, gathered, exploded during a very long time but
Interviewer: Um. Ok, so what happens now if you were to describe the development of the universe at the moment?
Adam: Yes, for the moment we are to a large extent, we have spread out to a large extent
Interviewer: Mm
Adam: and yes black holes for example gather matter, attract matter.
/.../
Adam: /.../ and finally we will be lumped together so that we become a gigantic black hole, maybe that I don't know.

The universe that has developed since the latest explosion is not unique in Adam's view. For example he states that life could very well develop in the next cycle of the universe as well. Adam does not believe that there is life only on Earth in the universe of today. Instead he states that some kind of life probably exists elsewhere in the universe too. Life could start to develop first on the most central places in the universe, and later on places further away. This is because the matter that these planets were formed of have, in Adams view, stopped earlier after the explosion (due to the shorter distance).

Adam believes that the elements were present in the matter gathered before the Big Bang. He is not certain of where the matter comes from, neither for his own part nor for physics. At this point he says that even though he believes in a cyclical universe he thinks that there must have been some sort of beginning where the original matter was created. Since then the elements according to him has been there through all the cycles. When describing the physics view he states that he believes that the elements according to physics were created very early after the Big Bang. The first elements that came up were hydrogen and helium. But all the elements were created very early after the explosion started.

Adam does not seem to have any problems with his own view differing from the view he describes as the view of physics.

Adam: I think that we should believe in ourselves. Sure it will not always be correct and very often we will be proven wrong but /.../ not proven theories... are just theories and so far there are only theories for how the earth came to be. No one has proven how it is, and that's that, and therefore I think we should be allowed to speculate ourselves.

Lisa's Story About the Universe, Physics and Herself:

Lisa says that she is interested in the universe. When discussing her view of the origin and development of the universe in the interview her religious faith seems

important to her. Her faith impresses her description of her own view of the universe, but it also seems very important to her to state that she also believes in the description of physics. Sometimes she has talked to friends about science and religion.

Lisa describes the physics view in saying that the universe was once in one point, which started to expand. She describes the expansion as a balloon that is blown up. Everything is moving away from one another. The metaphor of the surface of a balloon makes it possible to travel around the universe without reaching any border. She is, however, uncertain of whether or not something exists inside and outside of the balloon (universe). When asked about whether matter in the point that the universe started to expand from has always existed or whether it came to be in some way she thinks that according to physics something cannot come out of nothing:

Lisa:	I don't know what the physics says but... ... ... I don't know... it well it can't. I have difficulties in believing that the physics says that it, sort of, can have come something out of nothing
Interviewer:	Mm
Lisa:	So, something must have been there already from the beginning
Interviewer:	Mm.....and that would have been the small point or? ...Or would...
Lisa:	Yes, I don't know [laugh] but it must have been something, something must have been there
Interviewer:	Something must be there mm
Lisa:	But they...but I don't know what, but something has been there from the beginning I think
Interviewer:	Mm
Lisa:	because it can't, sort of, come out of nothing so
Interviewer:	No ok
Lisa:	Not according to physics

Lisa states explicitly that this is the view of physics. She herself believes in a god that created everything that existed in that small point. Her belief in a creating god is the very first thing she states when asked about her own view of the origin of the universe. At the same time she explains that this does not contradict the description of physics:

Lisa:	/.../ I still believe that humans and everything have, sort of, developed the way that scientists say, but that it still is God that has, or yes we can say God, that has made it from the beginning so to speak. So then I think that it is easier, sort of, that God has created the small stuff these tiny things that was in the point
Interviewer:	Mm okey
Lisa:	from the beginning and then...
Interviewer:	Mm that is from the beginning only God existed
Lisa:	Mm
Interviewer:	Or is that how you think? And then the small point was created
Lisa:	Ah like he already had seen or so /.../. He had planned it already [laugh]
Interviewer:	Ok, so everything was sort of mm the whole development since then have been planned from the beginning?
Lisa:	Mm

She agrees with the physics view of an expanding universe and believes that everything was planned by God from the very beginning. This includes the overall development of the universe, the formation of the planets and the emergence of life on earth. She also believes that the development of life can be described by the theory of evolution, but it was planned by God. Because it was very well planned, there is no need for him to intervene in the overall development even though he is able to. She does not believe that physics would say that it was planned. When asked explicitly about the physics view of predictability and chance she says that she does not believe that everything according to physics is predetermined, but it is not pure chance either.

Concerning the elements, Lisa believes that the physics view is that hydrogen was the first element that came up, and after that more heavy elements have been formed. This happened when lighter elements collided and merged. She states that all the elements that the planets consist of must have been created before the planets were formed. Some of the elements were created after the stars came to be. In this she agrees with the physics view even though she is uncertain of the time periods of the physics description.

She believes that the universe was created about 15 billion years ago. She is unsure about when the sun and the earth came to be. But she says that it was longer between the origin of the universe and the sun than between the origin of the sun and the earth. It was an even shorter time between the earth and the life on earth.

When asked about whether or not she believes that there is life on other planets she reasons both from a religious and a scientific starting point. When doing so she finds herself in a contradiction:

Interviewer:	Is earth the only place where there is life in the universe?
Lisa:	/.../ I think that it is hard because /.../ if you think about the existence of another planet that has the same conditions, so to say, that the earth has...It has to exist I think because the universe is so large that there must be another planet where life is possible. But then if you think that it's God who has created everything, then you can think that he has sort of ...sort of decided something special ...But since he is the only one who knows the meaning of everything...it is hard to know if he has thought.... well that he would compare for example how they are, kind of, getting on? [laugh] But well I don't believe that. I rather believe that he has in that case only created one earth
Interviewer:	Mm...so he planned from the beginning that he would start the development in a way that one earth with the...
Lisa:	Mm
Interviewer:	right conditions for...life
Lisa:	Mm
Interviewer:	But that it's only there?
Lisa:	Ah...but if you think, well, I don't I still believe that [?] the universe is so large that there should somehow exist another planet anyway...that, sort of, has the same conditions
Interviewer:	Then there would be life there as well?
Lisa:	Mm and then I contradict myself [laugh]
Interviewer:	Mm
Lisa:	No I don't know because...no but I th... mm...well it is hard
Interviewer:	Mm

Lisa: But I suppose I believe that there should be another planet that has the same conditions as the earth ...or that it exists another sort of life that can live... without oxygen for example / .../...But in that case I believe that if it exists I believe that God has planned that too, because I don't think that it, that anything that happens, happens out of chance, but...it is, sort of, fate or predetermined.

She eventually agrees with the results given by the more scientific reasoning, but in doing so she interprets it from a religious worldview as well.

Discussion

The two stories describe two rather different ways to handle the physics view. The first story – the story of Adam – describes a student that in his own view is inspired by physics concerning some aspects, while he in other aspects feels free to believe in another view than the view he connects with physics. This could be described as a combination of an anthropological way of learning and autonomous acculturation both described by Aikenhead (1996) – anthropological learning when taking another position than the one he describes as the physics view, not viewing the differences as a problem, and autonomous acculturation when using the physics view, for example the Big Bang, in a modified way when describing his own view. In the second story – the story of Lisa – it becomes clear that she is more concerned about the physics view than Adam seems to be. Lisa seems to think that it is important that the religious view does not contradict the view she connects with physics, and when it does, she seems to try to minimize the contradiction. In this she differs from Adam. In some aspects she comes to different conclusions concerning the universe when reasoning from the starting point of her religious faith compared to when she reasons from what she thinks is a scientific starting point. When this happens she tends to negotiate and reinterpret the religious view. This is the case when she discusses the possibility of life at other places in the universe. Except from the origin of the first matter in the universe, where she practise anthropological learning, her overall view can be described as equal to the view of physics in what the development of the universe has been like, but different in that she believes that this development was predicted from the very beginning. This is an element in her worldview that comes from her religious conviction, in which God planned the development from the very beginning. Lisa can be described as an example of a student using autonomous acculturation (in interpreting the scientific view within the frame of reference of a religious worldview) more frequently than anthropological learning.

Both Adam and Lisa can be described as practising autonomous acculturation in the area of cosmology. They use the science view and in different ways they combine it with other things they believe in. The two of them practise anthropological learning as well. Most frequently this type of cross-cultural learning is

used by Adam who does not view the differences in his description of the physics view and his own view as a problem.

Conclusions and Implications for Teaching

This study shows that students' views of the physics models related to the beginning and development of the universe differ a lot, even though most of the students refer to the Big Bang model when describing the physics view. The students do not show a pronounced understanding of the theoretical models. There are many reasons for this. One could be that cosmology often is treated very briefly during the physics courses. A second reason could be that the students themselves have presuppositions (Cobern, 1996) about what the world is like – for example that the universe has always existed or that something cannot come out of nothing – through which they try to understand also the physics view. We argue that it is impossible for the students to understand the scientific models in a meaningful way without knowing about the presuppositions (Cobern, 2000; Poole, 1998) that underpin these models. To help these students learn about the physics view we therefore argue for a discussion in science class about the presuppositions that underpin science and how these are related to the presuppositions that the students themselves have about the world. The discussion should not, in our view, have the aim of convincing the students about the physics view. Instead the teaching should have a cross-cultural approach (Aikenhead, 1996), where the students learn about the physics culture and the views associated with it without necessarily take these to be their own.

We have seen that when telling us about their own view, many students relate to the view that they have described as the view of physics, but this is done in different ways by the students. It is interesting to note that some students agree completely with their view of the physics views, while others describe a different view or modify the physics view so that it suits their view of what the universe is like. This is done for example by combining the physical view of a universe, which ones was extremely small, with their own assumption that the universe has always existed in some way. Examples are uses of a cyclical view of the universe or when the Big Bang is described as a transformation of the universe into the kind of universe we have today. It is obvious from the study that it is not necessarily the case that students, even when knowing about the physics view, also make this view their own. Cobern (1996) supports this by saying:

> /.../ *comprehension does not necessitate apprehension.* One may well reject a concept that he or she fully comprehends while someone else apprehends it as knowledge. (Cobern, 1996, p. 592).

This has in previous studies been exemplified in the area of evolution (Dagher & BouJaoude, 1997) and in the area of relativity (Brewer & Chinn, 1991), and in this article we have reported on different kinds of "crosscultural learning" (Aikenhead,

1996; Cobern & Aikenhead, 1998) used by the students in the area of cosmology. There are examples in the data of students practising autonomous acculturation as well as anthropological learning. This adds to a traditional conceptual change model (Posner, Strike, Hewson, & Gertzog, 1982) where one does not discuss the possibility that a student understands the scientific view without taking it to be their own view. We claim that a student could very well understand a specific scientific model, and understand why this view from the physics point of view is both plausible and fruitful (Posner et al., 1982) even though his or her own view of what is plausible and fruitful is different.

The students we in this study have seen practising autonomous acculturation and/or anthropological learning are students who have chosen to study science and physics and, at least in the area of cosmology, have found a way to deal with the scientific view, even though this, in parts, differs from their own view of the world. Whether or not these students if they in the future would reach a deepened understanding of the physics view also will take this to be their own view is not possible to say. For some students this could be the case – students who use anthropological learning or autonomous acculturation could very well later be enculturated into the science culture and take the views of this culture to be their own. For other students the presuppositions that they have about the world are so strong that they probably will not change them. For both groups a cross-cultural approach to learning science will be an unthreatening way to learn science without a pressure to leave their own views behind. We are arguing that an explicit opportunity to learn science content through anthropological learning or autonomous acculturation (Aikenhead, 1996), would give more students than those that invent these types of learning themselves the possibility to learn science in a meaningful way even though their worldviews differ from the scientific worldview.

There are students who combine a scientific view with a religious worldview. Some of them state explicitly that they also believe in the physics view, which is obviously important for them to stress. This can be understood through the writings of Brickhouse (2001) and Lemke (2001) about science education being an identity issue, and statements in this study (mostly done by students taking a non-religious position) about being a science student implies believing in the models of science. This is probably important also for the religious students who explicitly state that their religious view is compatible with science. Görman (2000) has shown that people in Sweden think that knowledge about the Big Bang model has made them less inclined to believe in a god, and we have seen from this study that it is important for the religious students to show that physics and religion are compatible for them regarding the origin of the universe. This is very interesting to study from a science education perspective. Discussions of religious convictions and other basic presupposition about the world are important within science class. We propose that teaching about cosmology would benefit from including these discussions. It would make clear to the students the

presuppositions that are really necessary for the scientific description. We are elsewhere (Hansson & Redfors, 2005) discussing what views the students' associate with physics concerning presuppositions that are usually associated with traditional religions.

We are continuing the project in order to investigate in more detail students' views of which presuppositions that are associated with science (physics). We are also addressing how this issue could be made part of science teaching. A teaching sequence about cosmology will be developed and tried out in cooperation with upper-secondary school teachers.

Notes

1. We view physics as a culture (Aikenhead, 1996) with views and values. In this article we use the expressions 'the physics view' and 'the view of physics for these views, and take them both to mean the same thing.
2. Q1 stands for Question 1 in the survey.
3. 18 students relate to God or religion in their answers to the question about whether or not there is a beginning of the universe. No direct question was asked about whether or not the students believe that a god or supreme being had something to do with the origin and/or development of the universe.

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Appendix A. The Three Questions in the Survey that are the Focus of this Analysis

Question 1:

Has the universe always existed or does it have a beginning?
If it has always existed how can you explain this? If it has a beginning what made it come into be?
Explain as precisely as you can how you think about **the physics** view of this.

Has the universe always existed or does it have a beginning?
If it has always existed how can you explain this? If it has a beginning what made it come into be?
Explain as precisely as you can how **you yourself** think about this.

Question 2*:

Does the universe change or is it unchangeable? How can this be described?
Explain as precisely as you can how you think about **the physics** view of this.

Does the universe change or is it unchangeable? How can this be described?
Explain as precisely as you can how **you yourself** think about this.

* In the pilot study "If it changes describe how." was used instead of "How can this be described?"

Question 5:

Where do the elements come from that are necessary for the life on earth, for example carbon, oxygen and nitrogen?
Explain as precisely as you can how you think about **the physics** view of this.

Where do the elements come from that are necessary for the life on earth, for example carbon, oxygen and nitrogen?
Explain as precisely as you can how **you yourself** think about this.

Appendix B

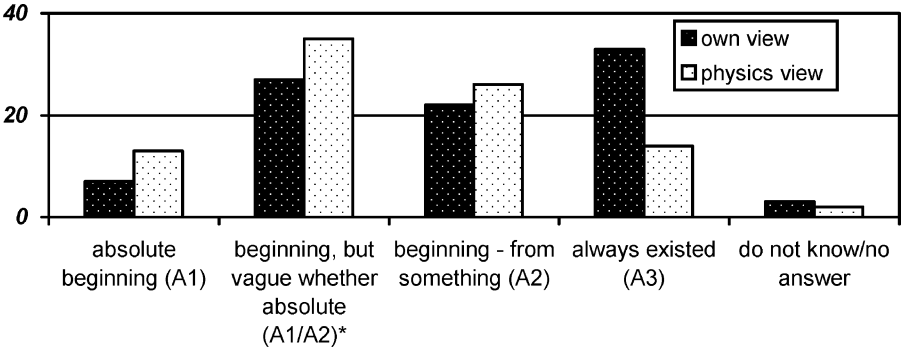

Figure 2: Students' own views and their views of the physics views of the origin of the universe (number of students who expressed the different views in the survey).

*It is rather common in the written survey that the students describe a beginning of the universe, without being explicit about whether or not this beginning is an absolute one. These statements are categorised as *Beginning – vague whether absolute*. We do not think that there is another view "hidden" in the answers categorised as *Beginning but vague whether absolute* (A1/2). From the data we conclude that these students either do not know or have one of the views described above.

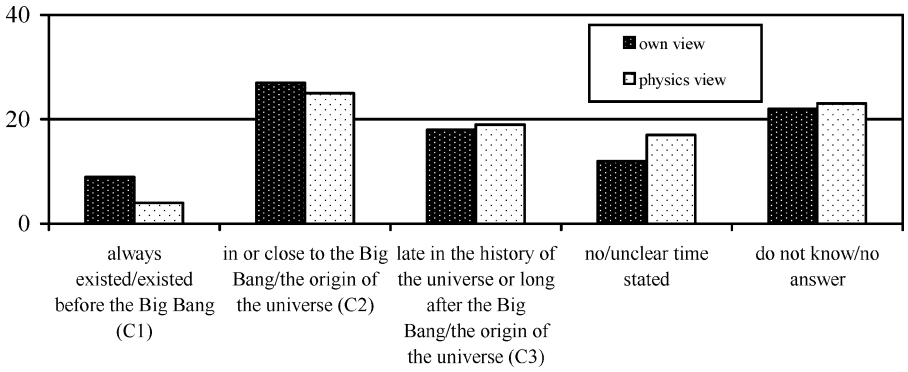

Figure 3: View of when the elements came to be* (number of students who expressed the different views in the survey).

*The categories are focusing when the elements exemplified in the question were formed, not how it happened. Because of this, statements that are similar in describing how the elements came to be (for example saying that the more complex elements came to be when the less complex collided), but different in when this happened, are categorised in different categories.

Table 2
Changes Mentioned by The Students When Describing How the Universe Changes According to Physics (Some Students' Statements have been Categorised in More than One Category).

Category	Number of students
The universe expand/grow	55
Stars are born and/or die	23
Other examples of changes	17
Unspecified changes	8
Other answers	1
No answer	5