

Conference on Astrophysical Ages and Time Scales

Hilo, Hawaii 5 – 9 February 2001

**Introduction
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Governor Cayetano, Mayor Kim, ladies and gentlemen, friends and colleagues, it is my pleasure on behalf of the Gemini Observatory, the Subaru Telescope, and the Scientific Organizing Committee to welcome you all to this Conference on Astrophysical Ages and Time Scales here in Hilo, Hawaii.

With the world's most powerful telescopes here on Mauna Kea, Hawaii is now becoming a natural place to hold such conferences, and this will just be the first in a series of such meetings, where the world's astronomers not only get an opportunity to talk to each other, but also get an opportunity to talk to the public, the children of Hawaii (through their science teachers some of whom are with us here today), and even to the political leaders of Hawaii about the excitement of astronomy, the unfolding picture of our Universe, and our place in it. Even though astronomy is becoming an industry in its own right here in Hawaii, generating perhaps \$150M a year in economic activity, this is not the reason or even the justification for undertaking these great endeavors. Ever since Galileo first turned his telescope to Jupiter over four hundred years ago, and saw the orbiting Jovian moons, telescopes, the tools of observational astronomy, have had the power to transform our view of the Universe, and our place in it.

So why have we called a conference on Astrophysical Ages and Time Scales? When Ted von Hippel (here) first brought the idea to my office over a year ago, the scientific community was still reeling from the ruling of the Kansas School Board that evolution should be taught on equal par to creationism, we are also faced with books declaring "the End of Science". The very foundations of the scientific journey that humanity has been on over the last four hundred years were being shaken and challenged by the very public on whose support we had (perhaps rather arrogantly) unequivocally counted on over the last several decades.

And yet it is this same moment that we stand at a place in our history of profound revelation, based on a remarkable period of breathtaking discoveries, discoveries that make us perhaps one of the most privileged generations in the collective history of our species. Within the last hundred years, our view of our Universe, has not just been transformed, it has undergone a revolution as we have begun to realize the enormity of the scale our Universe and have had the audacity to try and piece together its immense history.

We are all now aware of the tremendous distances that exist between stars, and we all talk quite casually of the millions of light years that separate Galaxies, and we even construct pictures of our Universe where we represent whole clusters of galaxies as just

single points scattered across regions of space of an almost unimaginable scale. However, it is sometimes not realized by many outside the field of astronomy, that this same description of our Universe stretches over not only unimaginable scales, but also across an enormous expanse of time.

In 1654, Bishop Lightfoot concluded *that “heaven and earth, center and circumference, were created together, in the same instant, and that this work took place on the twenty third of October 4004 BC, at nine o’clock in the morning”* Though we may be somewhat startled by the confidence of this conclusion, Bishop Lightfoot was a man of great integrity (and the Vice-Chancellor of the University of Cambridge) and there was scant evidence to contradict such a declaration. It wasn’t until the latter part of the 19th Century that Darwin postulated that evolution required much more than 40 million years to evolve complex organisms, only to be told by the Scottish physicist Lord Kelvin, that he had definitively proved the Earth could be no older than between 20m – 40m years old.

It wasn’t until the twentieth century, with the advent of modern observation astronomy, the development of the theory of stellar evolution and the discovery of radioactive decay that these first, fiercely fought scientific contradictions began to be resolved as we glimpsed the first hints of the “unimaginable timescales” involved in the Earths history. Today, just a little under a hundred years after the American Physicist Bertram Boltwood first measured the radio active decay in rocks and realized the appropriate unit for measuring ages was not “millions of years” but “billions of years”, astronomers using telescopes both on the ground and orbiting in space, combined with extraordinary insights from a generation of scientists, have established that a clock has been ticking in this Universe for at least the last 13 – 15 billion years.

If my professional colleagues will indulge me for a few moments, let me try and place this timescale into some perspective for those of you not used to using “billions of years” as a natural unit for measuring “how long things take” (unless of course you live in Hilo and have been waiting for the plumber to return your call).

Imagine the 14 billion year history of our Universe is stretched over the ocean between San Francisco and here. 2500 miles of ocean will represent the last 14 billion years of history. We will start our 2500-mile journey with the rising sun in San Francisco, at the moment of the “Big Bang”, and roll the Universes history forward by traveling across our “ocean of time” and reaching the present, landfall here in Hilo Bay some 14 billion years later. Every foot we travel will be the equivalent to the passage of a thousand years, every mile covered will mark the passing of almost 6 million years. So we set out for our journey from a point many cultures share, “a beginning”. Here in Hawaii, Will Kyselka in his book on the navigator Nainoa Thompson *“An Ocean in Mind”* describes this moment in the Hawaiian oral tradition as *“a moment longer than anyone can remember or even imagine – there were no stars in the sky, all was darkness, Cosmic darkness – po.”* From that beginning, we have to travel over 17 hundred miles of our 25 hundred mile journey, over two-thirds of the way across “our ocean”, before we come to the point some 4.5 billions years ago when the Sun and Earth formed out of its placental molecular cloud. Though this was our “first event”, we know from the Sun’s composition, that on

our journey we must have passed over at least one, possibly several generations of stars that lived and died before our sun could have been created. At this point in our ocean journey, we are now 800 miles off the coast of Hawaii. We have to travel a further 799 and 1/2 miles, within half a mile of the coast here in Hawaii before we find the first evidence of our hominid ancestors, some three millions years ago, whose successors will use the last half mile of this journey to completely populate this planet. And it's only when we get to within a hundred yards of Hilo that this island begins to appear some 4 hundred thousand years ago. And when we are within the last 10 feet of the shoreline here, we are within the entirety of recorded human history. The sum total of our entire 10 thousand year history as a human race, every migration, every journey undertaken, the rise and fall of every empire, every war ever fought, every weather-worn monument to grandeur ever erected, every moment of despair, every moment of hope experienced by any man, woman or child who has ever existed, resides only in this last 10 foot stretch of our ocean of time. Our entire collective history is contained within the length of a single rolling wave, no more than ten foot long at the very end of this 25 hundred mile oceanic journey. And perhaps more remarkable still, it is only within the last inch of our 2500 mile ocean journey, within the last 100 years that we come to the point where, for the first time, we are able to build telescopes and instruments that can look back over to our 14 billion year journey through time.

And this is why our generation is so privileged. This is why, as astronomers, we are so excited. We find ourselves, in the last line of white foam at the end of the last wave of this 25 hundred mile oceanic journey, able for the first time as a species to come to terms with the enormity of the scale and age of the Universe in which we exist. And so here in Hilo, the landfall of our 14 billion year journey, we are hoping to debate and examine the timescale and ages of the key events and processes that are used to re-construct this remarkable history of our Universe. Our yards sticks are far from perfect; there are still many contradictions and uncertainties. In fact it may surprise many of the public at large that astronomers have learned a little humility. In 1654, Bishop Lightfoot felt able to define the time of creation to a precision of one hour in 5,658 years. This is an accuracy of one part in 50 million. Though our 21st Century estimates for this time scale is several million times longer, today we feel able only to quote the time from creation to a precision of 1 part in 7, a seven-fold decrease in presumed accuracy. Throughout this week, we will be discussing the errors and assumptions that contribute to these uncertainties and air our disagreements and agreements, which will ultimately form our statement of the status of Astrophysical Ages and Time Scales as seen by the astronomical community in the year 2001.

In addition, through the public lectures, and perhaps through the conference proceedings that will follow, I hope that many more people will get to see "astronomy at work", and share some of the excitement and awe many of us experience as we study our cosmos, and perhaps encounter what Carl Sagan once described as the "*humbling*", yet "*character building experience*" of astronomy.

I would now like to ask Kupuna Leilehua Omphroy to begin the Conference with a traditional Hawaiian blessing.

