
HK: Welcome to a "Conversation With History." I'm Harry Kreisler of the Institute of International Studies. Our guest today is Gibor Basri who is professor of astronomy at UC Berkeley. He is also the vice chancellor for equity and inclusion. Gibor, welcome to our program.

GB: Thanks, Harry.

HK: Where were you born and raised?

GB: I was born in New York City but I wasn't raised there. I left when I was about two and was raised in Colorado, Fort Collins, which is now the home of Colorado State University.

HK: And what is the origin of your name? It's a unique, very interesting name.

GB: Well, this is one of those only-in-America kind of stories. My father is an Iraqi Jew and my mother is Jamaican, but my name is from my father's side. Gibor is a Hebrew name that means something like "strong hero," and Basri really means "from Basra." So, his family was in Basra, Iraq.

HK: And I understand from a faculty colleague here that before World War I the Jewish community in Iraq was the largest minority.

GB: Yeah, and in fact, they had been there since the time of Nebuchadnezzar, so this is a biblical story, really. The Jews were captured, they were taken to Babylon, then they were released by Cyrus of Persia, seventy years later. Some of them stayed in Babylon and some went back to Israel. The ones who stayed were then a contiguous Jewish community up until, actually, the formation of the State of Israel, when they finally went back twenty-five hundred years later.

HK: And looking back, how do you think your parents shaped your thinking about the world?

GB: Well, the other thing that I can mention is that we did live overseas for two different years when I was growing up, and that had a big influence on my view of the world. We lived in Burma when I was five years old and we lived in Sri Lanka when I was fifteen, and in both instances we took about three months getting there and three months getting back, circumnavigating the globe each time. So, I did get to see a lot of the world and I lived in sort of these third world countries, and so that certainly gave me a view that was beyond my little upbringing in Colorado.

HK: So, you saw so much of the world when you were younger that you then had to devote your career to studying the universe, I guess. [laughs]

GB: Well, that's right, but what I hadn't understood was that astronomy is also a very traveling profession, and so I've traveled quite a bit as an astronomer, too. I enjoy traveling.

HK: Well, we'll talk about that in a minute. So, was your father a professor? Did I read that in your…?

GB: Yes, that's right. He was a professor of physics.

HK: I see. In Colorado?

GB: In Colorado.

HK: Right. So, was there talk about science and scientific experiments, and physics, around the dinner table?

GB: Yes, sometimes. He was a theoretical physicist, so he didn't actually work with any equipment. He was a mathematician, really, but of course he talked about the problems in physics, and so on. My mother, on the other hand, was a dancer, so she had the arts covered.

HK: And so, the two trajectories of their lives seem like – you could see how they might have influenced your trajectory.

GB: Well, yeah. I mean, I think I came to astronomy sort of myself, really through science fiction. When I started reading I found that I really liked science fiction right away. But then my father was happy to encourage my interest in the physical world, and the stars, and so on. So, he was always in favor of my thinking about, and studying, astronomy.

HK: What was it about science fiction that drew you in?

GB: That's the hard question, is why that and why not something else. It was something about the exploring new places, the last frontier – I don't know – the idea of space caught my imagination right away.

HK: Were there any teachers that you had in high school, or earlier, that really were influential in making you understand things about science that you hadn't gotten at home?

GB: No, the science teachers in Fort Collins were not that exciting, but my father was, and then I met Arthur C. Clarke. He lived in Sri Lanka, so I met him when we lived there. That, of course, was a huge thrill for me, and so science fiction became even a bigger part of my thinking.

HK: Talk about that impact. That would be interesting. I mean, what was it like for a young person to actually be into science fiction and meet Arthur Clarke?

GB: Oh, it was a tremendous thrill, and at the time he was working on a movie with Stanley Kubrick, "2001." They hadn't finished it at the time, so he was telling me about what they were doing and how it was going to be really exciting and kind of groundbreaking. I didn't see it in Sri Lanka, when I got back to the States I saw it and was tremendously impressed. But I'd been a big fan of Clarke before that, and so every time we would chat it was just very exciting for me. Then I lost track of him for – actually he came and visited us in Colorado once, after that, a few years later, when he came for one of the moon shots. And then I sort of lost track of him. And then one of the post-doc researchers here at Berkeley, much later – this was only a few years ago – was from Sri Lanka, he knew Clarke, and so we got back in touch, and then I stayed in touch with him until he died.

HK: And was he living there?

GB: Yeah, he was continuing to live in Sri Lanka.

HK: I see. And where did you do your undergraduate work?

GB: That I did at Stanford. So, I went west from Colorado and after I finished at Stanford I actually went back to Colorado for my graduate work, and then I came back out to the Bay Area. So, I knew two great places to live and I've been kind of bouncing back and forth.

HK: And at Stanford did you go right for the science?

GB: Yeah, I went there intending to major in physics and did so, but what happened was I found it difficult and only if I was properly motivated was it something I really wanted to do, and I realized the only motivation I have is if I could do astrophysics. Then I was happy to do it. So, that made me decide to go to graduate school in astrophysics.

HK: So, getting back to Clarke, do you think he was key to pushing you toward the stars?

GB: You know, that certainly reinforced my enthusiasm for it, yes.

HK: Now I noticed that your dissertation was on supergiant chromospheres. Tell us what that was about.

GB: Stars come in various sizes and astronomers like to use dwarfs, giants and supergiants to sort of describe the sizes. So, supergiants are just what it sounds like, they're the largest stars. I was interested in supergiants because they have really low gravities at their surfaces. Basically, a supergiant, if you put it in place of the sun, it might extend out to the orbit of Mars. So, it's an enormous star, but most of that is really very vaporous. Most of the mass of the star is down near the center. And so, the atmosphere, where you can see the apparent boundary of the star, is very low density and distended, and that leads to some very interesting effects in spectroscopy, which is the tool I use in astrophysics. So, that was my thesis title, that's what I wrote it on, but I actually did my first paper on our sun and I have returned to our sun at various times during my research career, and for the most part, actually, I study dwarf stars, not giants or supergiants, now.

HK: Let's talk a little about doing science and doing astronomy. What are the skills required, analytic and other?

GB: Yeah. These days, if you want to be an astronomer, you really have to have a good grounding in physics. So, a lot of graduate students in astronomy actually are physics majors or they've had a very strong physics background. Astronomy works really well at the beginning, sort of introductory, even non-mathematical, it's really exciting, it's fun, there're tons of great pictures, and so on. Then you have to get through the physics part, so that gets tough sledding for a while, and then when you get back to graduate school you start studying astrophysics again, and it becomes kind of less formalized. It depends on what kind of astronomy you're doing, or astrophysics. People do theory, they do cosmology, they study stars, they study galaxies, study the interstellar medium, so what kind of skills you need depends a little bit on which of those areas you're going into.

HK: Besides math, which is obviously necessary, is it important to have kind of a broader cultural background? I mean, would you recommend taking courses in areas that are not science?

GB: Well, I would recommend that because I believe in well-rounded people. It's not required for astronomy, to do that. I think a lot of astronomers do have other interests, but astronomy itself – what you really need is not just the math but, I think, some kind of a physical intuition and an ability to synthesize, because astronomical objects are typically complicated systems, like a planet or a star. There's a lot going on, there're a lot of different things to think about. So, I think the ability to synthesize a lot of different things into one coherent picture – that's an important ability.

HK: When you say "physical intuition" – explain that a little further.

GB: Well, let's see – I guess, for example, in the area of radiative transfer, trying to understand the light from the stars, how it comes out through the star's atmosphere, gaining information that we can then get by observing the star. So, for example, understanding that if it's a distended, low gravity atmosphere, that's going to have certain effects on the spectral lines, as opposed to a compact, dense atmosphere. You wouldn't know what those effects were until you had studied physics, but then you'd begin to develop an intuition about it, so you see a new spectrum and somebody says, this is such-and-such, and you think, "Well, yeah, but that ought to really look different, if it was that." And so, having an intuition about how things work in the cosmos is important because a lot of – astronomy is kind of in a discovery phase, so a lot of times you'll be looking at something that no one has ever seen before. Then you need your intuition to tell you what might this be and what would be the best way to investigate this. At the beginning, that's sort of intuitive. Then when you get into the details, you get more formal, or maybe mathematical, maybe instrumental, whatever it is.

HK: In some of your writings, papers that I read, I noticed the point was – which relates to this, namely that sometimes you're looking for something that isn't seen and therefore you look for side effects from which you can theorize about what is there, even though you don't see it.

GB: Right. Well, you know, astronomy – at the base of it is kind of like that, too, because we can never get our hands on what we're studying. So, you have to infer almost everything, actually, from rather little. We get little trickles of starlight, we do various things with that, and from that we infer all kinds of things about what the star's doing. So, there is – in some ways it's all indirect in that sense. We never get to go do an experiment there, we never get to go visit the object, except in our own solar system occasionally, but for the rest of the cosmos it's all kind of a detective novel. You have clues and you try to put together what's going on, but you never get to go check, actually.

HK: So then, tell us a little about the non-academic virtues that are required to be an astronomer. You just referred to detective work. I guess you also have to be adventuresome.

GB: Yeah. I think astronomers are adventuresome. You know, you go on mountaintops to do the observations – a lot of people I know like to hike, or mountain-climb, whatever – and you have to want to sort of go…

HK: Where man has not gone before. [laughs]

GB: Yeah, I just realized that's a terrible cliché but that's true. That's really the attraction of it, is seeing stuff that hasn't been seen before, which has been really possible in my career because technology has improved amazingly much during my career. And so, we're constantly able to make observations that you simply couldn't make before, and then you see things people have never seen.

HK: Are astronomers dreamers? In the culture you sort of associate the stars with someone who is dreaming – I mean, the stars up in the sky. Talk a little about that. Is that just a superficial comment?

GB: I think most astronomers – I'm not sure I want to say dreamers as much as sort of philosophers. I think when you're confronted with the cosmos it's a sort of philosophical experience. Especially people who work on the origin of the universe, and all of us, are interested in that, or the question of other planets, and life on other planets. These are kind of deep philosophical questions which humanity has been asking itself forever. And so, to be an astronomer kind of puts you, right away, into that realm of these big philosophical questions.

HK: And is it that we're so small and the universe seems to be so great, and you're trying to understand what's out there and at the same time how we fit in, that is, humankind?

GB: Yeah, I think that's one of the great puzzlements one gets early, as you study astronomy. I teach astro 10 and the first thing I talk about is the scale of the universe, and it's very puzzling, why we're so small and it's so big, and why it's so empty. When you really sit down and ask, what's the scale of the earth and the sun and the distance between them, and the distance to the nearest star, you realize that the universe is practically entirely empty. The old saying, "nature abhors a vacuum," is probably one of the most wrong statements that's ever been made. Nature practically is a vacuum. There're just little bits and pieces of non-vacuum here and there. And so, yeah, it's a little hard to relate that to the human experience. We don't experience vacuum and things are kind of human scale for us, but when you study astronomy you end up thinking about not only really different scales in space but also really different scales of time. You have to start thinking – sometimes a million years seems like a really short time in astronomy and sometimes it seems like a long time. So, you have to be able to really be flexible about the scale that you're thinking on.

HK: How, in this context, does being an astronomer change your values, in a way? Because as you explore these great mysteries it really must focus your mind on what it all means, and so on.

GB: Yeah. Now I think different astronomers have different takes on what it all means or how they deal with it. Certainly for me, it's a major part of my world view. I think it means – people, for example, worry about what's going to happen to humanity, and so on. Well, from my point of view, humanity is going to be a brief flicker in the history of the earth. This is part of my science fiction, as well, of course, but studying long time spans, it's pretty clear that human beings as we know them today aren't going to last very long on astronomical time scales. Maybe our descendents will, maybe they'll be far superior to us, maybe we'll wipe ourselves out, but standard issue humans are not going to last very long at all in the universe. And so, that puts a certain perspective on it. And then as I said, the scale of things is unimaginably vast compared to the earth and us, and so, again, kind of what we're doing here is really very isolated in space and time. On the other hand, here we are, and so that leads me to the thought that we have to supply our own meaning to these things. Asking these questions of the universe, you get back answers that are inhuman, so I think humans have to come to their own terms with these things. And so, I think it's actually very important that we supply our own meaning and try to understand things on our own scale, because if you look to the universe you're just not going to get an answer you can even comprehend.

HK: I noticed on your website there was a paper trying to mathematically answer the question, is ET out there, really. There was some whimsy in the paper, but what about that whole problem of are they out there, and are they like us, and are they sending us signals?

GB: Right. I think that's a really interesting problem and I have it on my website because it's not that hard to sort of understand what the problem boils down to. So, actually, since I've started my career, we've come a certain amount of the distance to answering the question, only a little bit, but now we – when I started, I used to teach my class, well, we think there're probably planets around other starts but we don't have any actual evidence of that. Now that's changed, so we know that there are planets around other stars, we know there are actually quite a few. I'm involved currently with an experiment which is now doing that same question for earth-sized planets, so we actually still don't know what the frequency of earth-sized planets is but we will know in probably five years. So, you can do that, but then you start running into biology. If you have an earth-sized planet, it's going around a star, it's the right distance, and so on, what's the likelihood that life will arise? Now we have to start guessing some more, but what you can do is you can go through and you can be optimistic or pessimistic. If you're pessimistic, you can quickly show that we're the only life in our galaxy, so that's not very interesting. The question is, what happens if you're optimistic. So, you put an optimistic answer to each of these questions: how many planets; how many of them have life; how many that have life involve intelligent life, and so on. And then you come to a time question at the end of it, and the time question is the crucial one, it turns out. So, depending on how long civilizations last, there could be lots of them, or we might still be the only one. If it turns out that once you get a technological civilization, it tends to wipe itself out in a few centuries, then it's very likely we're the only one at the moment in the galaxy, and we'll wipe ourselves out, and then sometime later another one will arise and immediately wipe itself out, and like little flashbulbs going off, they'll never get to talk to each other because they don't stay long enough. And it turns out that the answer, if you want the galaxy to be populated with lots of civilizations that could talk to each other, [is] they have to live for astronomical lengths of time, at least millions of years. And then being optimistic about the other stuff, then you think the galaxy is well populated. So, it's interesting that there's all this astronomy, and so on, but at the end of the day, it boils down to, are we capable of being technological and not destroying ourselves. That's actually the crucial question, and how common is that.

HK: Before we talk about your research, I'm curious as to how you see creativity in astronomy. Is there something unique about the work there, or is it like creativity in the other sciences?

GB: I think it's like creativity in the other sciences. I think each scientist has a certain fund of knowledge that they draw on, they have a certain class of problems that they work with, and if they're a good scientist they're kind of up to speed. So, they know where the frontier of knowledge is, and then you just need to identify a problem that is both interesting to you and interesting in your science and work on that. The exact way you go about it is very different in the different sciences, but I think the creative process itself is probably similar.

HK: Now in talking about your research – and again, I'm not a scientist but I found your work fascinating – you've been involved in the debate about what is a planet, and I think that's a nice entry point into your own research in brown dwarfs. Why do we have to answer that question about what is a planet, and why all these fights?

GB: Okay. Well, that's partly caused by our advancing knowledge. I came into the debate, as you mentioned, from the upper end, that is from brown dwarfs, which are objects that are more massive than planets but less massive than stars. Brown dwarfs weren't known until 1995 or so, I was one of the early discoverers and I've worked on it since then. The first brown dwarfs we discovered were nearly the mass of stars and then we began to work our way down – they're harder to find if they're smaller and fainter, so it took a while but finally we found ourselves entering the domain where they were so small, or so low in mass, that you wondered whether they weren't really the same as planets. And there was the idea that – so, what is different about a planet and a brown dwarf in a star, and the idea was that a star is certainly – they are powered by fusion. Planets certainly are not, and brown dwarfs, it turns out, have some fusion but then they lose it after a little while, so that was intermediate. So, it seemed like fusion was a good dividing line between planets and brown dwarfs, but we eventually began finding objects which seemed to be so low in mass that you don't expect, from theoretical grounds, that they would ever have fusion, and then the question was, okay, what're we going to call those. And they weren't necessarily orbiting stars, they were just sitting there by themselves. So, were they free floating planets, were they sub-brown dwarfs? There began to be arguments and of course, part of it had to do with sort of the public relations value of it, so if you found another brown dwarf that was very low mass, that was one thing. If you found a free floating planet, that was much more exciting, you'd get in the newspaper more easily. And so, people began claiming that and other people began saying, well, that's not sensible, you can't have free floating planets, or we shouldn't call them that, or whatever; they're not made the same way that planets are made. Meanwhile in our solar system discoveries were happening out beyond Pluto. People were beginning to discover lots of objects out there, and eventually, of course, they started growing in size, and finally, one was found that was larger than Pluto and the question was, is that the tenth planet or should we actually kick Pluto out of the planet domain, as well. So, there was a debate going on there, too. Those two debates together made it clear that astronomers hadn't made up their minds about what a planet really is. And so, as I said, I got involved from the high mass end and some of my friends were involved from the low mass end, and then we tried to put it all together. It's not a settled question, though. I actually was just in New York, in March, for a tenth anniversary debate at the Rose Center, where they sort of started the Pluto controversy by opening this new planetarium and not calling Pluto a planet. So, we were still having a debate this past March.

HK: So, Pluto is not – I had heard of ex-presidents but I'd never heard of an ex-planet. Is it an ex-planet or is it still a planet?

GB: It depends on who you talk to. If you talk to me, it's still a planet. If you talk to other people, it's an ex-planet, but it's not the first ex-planet, actually. It turns out the asteroid Ceres, when it was discovered, was labeled a planet first, and in fact, it was sitting between Mars and Jupiter in an orbit where you expect, just based on the spacing of planets, to find a planet. So, they found it there and they said, oh, there's the next planet but it was awfully small. And then there were more and more, and so they decided to call them asteroids instead. So, Ceres had already lost its planetary status, and the same reasoning was then applied to Pluto. They said, well, it's part of a belt of lots of objects that it may be the biggest one – actually it's not even the biggest one – so, let's not call it a planet. That was the reasoning on that side. On the other side, one could reason that that's not the right definition for a planet. It has to do with – it's circumstantial. If you take the same object and you put it away from the belt, suddenly it's a planet; if you put it in the belt, it's not a planet. That doesn't seem like a good thing for planets, either. So, that's sort of what the debate's about, and because it's just a definitional debate, it's not really scientific. People can – you know, it's a matter of taste. Some people like Pluto as a planet and some people don't. [laughs]

HK: [laughs] Now you were a discoverer of one of the first brown dwarfs and it would be interesting to talk a little about how that search for dwarfs came about and the different routes that were taken, ending up with the route that you took. A lot of this is about hypothesizing and looking for things out there. Talk a little about this business about bipolar stars, two stars – if I'm…

GB: Binary stars?

HK: Yeah, sorry, binary stars – if there's one, there should be another.

GB: Well, that's not really related to the search for brown dwarfs. The search for brown dwarfs – so, brown dwarfs were expected to be lower in mass than stars and because fusion doesn't remain, when they first are formed they might look like really low mass stars but because they don't sustain fusion, then they begin to cool off and eventually they look more like planets, temperature-wise. So, there were a couple ways to search for them. One was to just look for objects that were so cool that even the coolest star couldn't be that cool; then you'd have a brown dwarf. But those would be very faint because they'd cooled off so much. The other approach, which I used, was let's look for them when they're nice and young and bright. But then the question is, how can you tell the difference between them and a star, and it turns out the element lithium gets destroyed by stars but it wouldn't get destroyed by brown dwarfs. And so, I was looking for what appeared to be very low mass stars but which showed lithium, and other people were looking for just really cool, faint things. And actually, in 1995 both methods paid off, that year, which seems to happen in science periodically. You've got a bunch of people looking and then all of a sudden it's successful on several fronts. Now how did I get into that? It actually had to do with the Keck telescopes, which the University of California and Cal Tech had just brought online. There were the world's largest telescopes. Because it was restricted in use to UC and Cal Tech astronomers, we all thought, well, this is an unparalleled opportunity, we should do something really exciting with this opportunity that we have over most of our colleagues. And so, I was working on relatively low mass stars anyway and I thought, "Oh, now I should hunt for brown dwarfs because if I do, that'll be a major discovery." So, that's how I sort of got involved in it, and I decided to go the lithium route because that required spectroscopy to carry out and I'm a spectroscopist, so it made sense.

HK: Do you name these objects?

GB: No, we don't name the brown dwarfs.

HK: Because…there're too many of them, potentially?

GB: Well, yeah, now that's true. Now there're too many of them, and the International Astronomical Union is the only body that has the official capacity to name astronomical objects and they don't name stars or star-like things. In fact – now they have named things in our solar system, so when XO planets were being discovered, that was a question, should they start naming those. But it turned out, again, enough were discovered quickly enough, they realized, no, let's not name them. Now they do name asteroids and there're tens of thousands of asteroids. Now the discoverer can kind of give it any name; as long as it's not off color, they'll take it for the name.

HK: If I could sum up what you're saying, to help our audience understand the work of astronomy, the technology is opening up the universe and what you have is almost like a mapping exercise, in a way, and a process for understanding how these objects differ from each other and finding different criteria to establish their differences. Is that…?

GB: Well, really, it's astrophysics. So, I wasn't actually interested in brown dwarfs because I just wanted to find out where a few were. Really, I wanted to study them physically. So, what's different about brown dwarfs and stars? Are our theories about this mass of object correct? How do we diagnose that? So, I'm not usually the discoverer of the object. The first lithium brown dwarf that I found – someone else found that object. I took the spectrum and I said, oh, this has lithium, and I did the theory showing how you use this lithium test to show that it's a brown dwarf. But then my interest was in the physical properties of that object, and then [in] the objects that were discovered later. So, I study things like the spin of brown dwarfs and how it's related to their magnetic fields, and the atmospheres, and as the temperature drops, the gas that's in the atmosphere begins to condense, actually, so that you begin to get these clouds, and there're clouds of iron and clouds of titanium in the atmospheres of brown dwarfs, and then as they get even cooler, those turn into dust grains and condense out and new things form. We haven't yet seen brown dwarfs that are so cool that they have ammonia or water clouds but we expect them to be out there. They're so faint that we just haven't been able to find any yet.

HK: And so, that is the element of the detective work that you were talking about earlier.

GB: Yeah.

HK: And these are all steps to understanding what the universe is about and how it came into being.

GB: Right. We really want a physical understanding of the universe. So, sometimes people draw the distinction between astronomy and astrophysics, where astronomy is more the mapping exercise and astrophysics is more about the physical properties. And I would say that there're very few astronomers, in that sense, left today. Almost everybody is an astrophysicist. We're really interested in how the universe works and how all the objects work, and also, how they come to be and how they die, what their evolution is, their life cycles, and so on.

HK: Now you were co-investigator of the Kepler mission. Tell us a little about that because that's where your research is going, and help us understand the importance of that and the way your mind works in exploring this opportunity.

GB: Well, you know, it's funny that you ask that because actually, last week I went down to NASA Ames, where the Kepler Science Center is, and saw the Kepler data for the first time. And over the weekend, I've just been like a kid in a candy shop because this is another one of these experiences where you're seeing data no one has ever seen before. It's of a quality and of a sort that simply hasn't been done before.

HK: And this is a NASA mission with a telescope that is producing this data.

GB: Right. And I'm a co-investigator; it means I helped write the proposal, to begin with. I had rather little to do with the building of the spacecraft, and design of the telescope, and so on. My role is really starting up now, to understand the data. But the mission itself is tremendously exciting. As we were talking earlier about the occurrence of life in the universe, the Kepler mission is the mission which should tell us, what is the frequency of earth-sized planets around other stars. So, that's the fundamental scientific mission of it, but the way it does that is it just simply looks at a whole bunch of stars, 150,000, measures their brightness to an extremely high precision, and does so continuously for three and a half years. And that kind of data we've never had before, actually, on stars. So, that data itself is just the brightness of every star, with extremely high precision over a long period of time. What we're looking for is a dip in that light. If a planet is orbiting a star, every time it crosses in front of it, it would knock out a little bit of light and we could see that as a signature in our so-called light curve. That's the idea behind the Kepler mission, so it's a one-meter-diameter space telescope; it's not orbiting the earth, it's actually sort of in a solar orbit, slowly drifting behind the earth but pointing at a fixed field of stars. It's just going to look at those very same stars the entire time, because you never know which star might have an earth-sized planet, you never know when it's going to go in front of the star, so you need to look all the time at the same stars so as not to miss anything. For me, I'm a stellar astrophysicist, so the hunt for planets is very exciting but while we're waiting for that, we're getting all this data on all these stars, so I'm getting 150,000 stars, I'm getting a brightness measurement every half-hour, continuously for three and a half years. There's a tremendous amount of potential stellar physics in that data set, and so that's what's keeping me excited in the meantime. The whole project, and the whole world really, is interested in the earth/planet answer, but as an astrophysicist I'm also interested in what the stars are doing.

HK: Are you looking for something or will what you're looking for come out as you familiarize yourself with this abundance of data?

GB: Both. I know some of the things that I'm looking because our sun has been observed in this way. That's really the only star for which we have very high precision measurements of its brightness for long, continuous amounts of time. And you see features in the solar light curve that correspond to sun spots, for example. If a sun spot comes around, that's a little darker than the rest of the sun, so the light in the sun drops a little bit. It turns out there're magnetic regions on the sun which actually make it a little brighter, too. You see this jagged curve that actually tells you something about how mottled the surface of the sun is. So, I know I can look for that on other stars and I don't expect every star to look like the sun at all. So, we know we're looking for that, but now I've seen the data and there's a lot of stuff in there that I actually don't have any idea what it is – why is it doing this, why is it doing that, so there's a great opportunity for discovery. We'll have to figure it out and it'll take us a while but eventually I'll be able to say, well, we learned that stars also do this or that, or they have these kinds of features that we didn't expect. And there's even some relevance to climate change on the earth. In the 17th century the sun kind of went blank and didn't have any sun spots for a while, and Europe anyway got substantially cooler then, and people don't really understand the sun/earth connection, exactly how that worked, but they've seen it happen more than once in the historical data. So, now I have 150,000 stars and they're kind of sun-like, most of them anyway. I can find out how many of those are kind of blank at the moment, and that would tell us what fraction of the time does the sun probably spend in this blank state and how likely is it that the earth gets subjected to those things, which seem to change the climate.

HK: Does this kind of research invite a broader interdisciplinary approach? In other words, is there something about this data, as you just suggested, is going to draw other sciences in, both for helping you understand but also in terms of breakthroughs in other areas?

GB: Yeah, I think so. And of course, the whole astrobiology question is a very broadly interdisciplinary question. So, another thing that we're expecting to see is, we hope we'll find earth-sized planets around low mass stars. Well, they'll have to be much closer to the star to get the same amount of heat because those are much fainter stars. And in fact, the planets will be tidily locked, so that one side of planet is always facing the star and the other side isn't. So, what's a planet like that like? Then atmospheric physicists need to come in and tell us, what kind of winds would you have. Are they going to distribute the heat from the bright side to the dark side enough to keep the planet hospitable, or will the atmosphere condense out on the back side and freeze? And then the biologists begin to start thinking about, well, what would that be like; some of these stars have huge magnetic flares on them that hit the planet with a lot of radiation. Is that good or bad for starting life? It makes a lot of complex molecules but then it might kill bacteria. So, yeah, there's a lot of interdisciplinary thinking that's beginning to happen around those kinds of questions, and I think the Kepler mission is certainly going to foster some of that.

HK: Another hat that you wear on the campus, besides professor of astronomy, is vice chancellor for equity and inclusion, and I think it's important to ask you, how do we draw in young people, especially from groups in our society, women, minorities and others, who've not been a part of the excitement of science but who have a lot to offer, if they get the right training and focus on these problems?

GB: Right. I mean, one simple way is what I'm going to do tomorrow, which is actually in this building. There'll be 250 minority students from around here and I'll give them a lecture about Kepler, and I hope they will see my infectious passion about it, and it's simple enough that they can kind of get the picture, and they can see me, that I look like them and I'm doing it. So, that's a small thing to do but that's one of the things. I've also been on the board of the Chabot Space and Science Center, which serves all the school districts around here, which gives them a better and more frequent look at some of the excitement of science. We really do need to encourage more people to go into science teaching, who are able to convey this excitement, as well. I think the problem with someone who lives in East Oakland thinking about being an astronomer is they don't know anybody who does anything remotely like that, and so it's not really in their thinking to do. Then the schools also have their under-resourced issues, and there aren't necessarily good math and science teachers to inspire them, and so we need to – the people who are doing it need to be out there as much as possible, showing that this is an exciting and satisfying career, and we need to be working on trying to get the educational system to prepare folks, so that if they choose to do that, that they actually have the preparation for it.

HK: Do you think we have an even more difficult challenge now because of all the problems with the international economy, the national economy, and the state economy, in a sense that, in a way, it also takes organization and dollars to make these things happen; we can't just depend on a charismatic scientists here or there?

GB: Yeah, that's right. As vice chancellor for equity and inclusion, I work with those programs and I see the budgets, and I see what's going to happen and is starting to happen because of this economic crisis, and I'm not happy about what I see. I mean, you have people who you are just beginning to bring into the fold and they're going to be the first ones that get left out when things shrink. If you're on the margins and the enterprise shrinks, you tend to get left out. And so, I'm quite worried about that happening. A perfect example of that is the Governor's suggestion to eliminate Cal Grants. That will fall disproportionately on people of low income and they are disproportionately under-represented minorities. So, something like that can have a large negative effect which is hard to counter with what we do, but we'll certainly forge ahead and try to do as much as we can.

HK: And do you think that at least now we have the virtue of a president who at least will attempt to motivate organizations and the system to actually try to reach out in a way that does not alienate people who feel that they're being excluded because more people are being included?

GB: Right.

HK: It's a dilemma.

GB: It is a dilemma, and of course, simply by his presence the President shows that there's a potential for going far to people who may not have thought it was there before. But yes, I also believe that he'll be more serious about putting resources where they're needed to help these populations who need more help, and right, at the same time do so in a way that is not too scary to the folks who are already well positioned, because they can also push pretty strongly against it. And of course, we've seen some of that in California, like with Prop 209, and so on, which definitely did have a negative effect on the participation of the whole population in especially the enterprise of the UC system, for example. So, yeah, we just have to – I mean, I think I'm – I was willing to take the job because I can take that same kind of point of view. I can work with everybody I need to work with in a reasonable fashion. I have a basic faith in people and I think they want to see the State of California succeed, and they recognize that it's a changing state. So, I have some hope, but of course, this current economic crisis is going to slow things down.

HK: What would be your advice to students out there who may or may not be minorities but who have an interest in astronomy after listening to you? How should they prepare for their future in astronomy?

GB: If you want to be an astronomer, you have to make sure you stay on the math track in middle and high school. If you don't do that, you're kind of left out in the cold to begin with. As I said earlier, you need to hover somewhere around physics, at least, to get the basics in. What I tell people, which was true for myself as well – actually, when I was in 8th grade I did a career report on astronomy because I was pretty interested at that point. It didn't look like a very good career to me, at that time. It was quite small, it was difficult to get into, there weren't that many jobs, so I actually gave up in 8th grade on being an astronomer. But I stayed in the math track and the physics track, knowing that at least that left that option open, and then as I said, at Stanford I realized if I'm going to do physics, it has to be astrophysics, and I went back to it. Even after I did that, though, I wasn't so sure I could end up as an astronomer, but I knew that the education I was getting would serve me well anyway. I was learning a lot about computers; there was no question I could've become a software person or a computer designer. There were a number of things I could've done, so I always felt that my options were open. And I think that people who study especially the hard sciences are attractive to business and industry, they develop a sort of analytic way of thinking, and a rigor of thinking, that a lot of different people value. So, usually when I talk to young people, I say, look, if you think you might want to do it, it's a good thing to do anyway, and if you don't end up doing it, you'll still be ahead of the game.

HK: Well, one final question, a brief answer. If Arthur Clarke is out there in the universe watching this program, what would be your thought to him about the influence of science fiction and what you do now, that interface?

GB: Well, I think Arthur Clarke saw some of his science fiction become reality in his own lifetime. You know, he predicted communication satellites, for example. And he and I talked about the possibility of life on other planets. I think he'd be really excited that we're just on the edge of discovering earths around other stars. And so, I would tell him, "You experienced science fiction turning into science fact in your life, and now I'm experiencing that, as well. And it's really a great feeling."

HK: On that note, I want to thank you, Gibor, for taking the time to be with us today. It was a fascinating conversation.

GB: Well, thank you so much for inviting me.

HK: And thank you for joining us for this "Conversation With History."

[End of Interview]