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ask not for less action in society by physicists but much, much more. What I fear is the narrow parochialism which seems to suggest that physicists should only care about physicists' human rights, chemists about chemists', Catholics about Catholics', Jews about Jews', and so on. Different human rights violations are surely not that incommensurable that a physicist should be more deeply moved by the harsh and repugnant treatment of the incredibly brave Sakharov than by the orders of magnitude worse treatment of as equally brave and significant a figure as Bishop Oscar Romero, and some tens of thousands of his compatriots in El Salvador.

Heicklen also propounds a new moral imperative: that one should spring into action as soon as "moral imperfection" is detected by our sensors. The problem with this is that the detectors used by the media, and often by ourselves, are selectively tuned to one or two frequencies. Jesus and other great religious leaders, partly for this reason, suggested that we should indeed, imperfect as we are, spring into action to eradicate moral imperfections, but that we should start (not finish) with ourselves, our community, our nation, and so on. I commend and support the Physical Society's efforts in the human rights area but add that the day when physicists could forget that they are citizens also is past. Thus I am astounded when colleagues passionately concerned about the imprisonment of scientists in the USSR have never even heard of the five persons, including two physicians, murdered for their political beliefs in Greensboro, North Carolina. Physicists may, I believe, earn the right to condemn the depredations against physicists only when they have calibrated themselves as citizens, by studying and condemning equal or worse depredations against other groups or individuals in society. Class-solipsism should be anathema to physicists.

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Mayan astronomy

I read with much interest the article "Native American Astronomy" by Anthony Aveni (June, page 24). His discussion of precise astronomical alignments in the surviving architecture of the ancient Maya depicting Venus, the Sun and Moon seems well-supported by the evidence presented. However, I thoroughly disagree with the "possible astronomical use" of the alignments in the Medicine Wheel with respect to bright stars, originally pro-



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posed by John Eddy.¹ As a matter of fact, I am a bit allergic to such alignments. Too many authors have seen alignments in sets of objects as different as quasars, megalithic stones in Cornwall, or Roman roads—alignments that have been assigned some profound (and often unspecified) meaning, but whose significance does not withstand a proper statistical analysis. The alignments with bright stars observed in the Medicine Wheel are in the same category, as will be shown in the following simple calculation.

The problem under investigation is as follows. Given a set of objects and a second set of randomly distributed objects, what is the *a priori* probability of finding a member of the second set aligned—within some acceptance angle—on two of the first set? Actually, the two sets may coincide with one another, as is the case for the megalithic stones. Broadbent has applied² some simple techniques to judge the significance of proposed alignments among those stones (he found that they are due to random coincidence); these techniques could also be applied to the proposed alignment with astronomical objects. In the present case, the second set consists of the rising positions of bright stars. How many such alignments are expected? This is very easy to calculate. The alignments about any 2 out of N stones point to $N!/2!(N-2)!$ positions on the eastern horizon. A bright star is considered to be aligned if its rising point falls within an angle ϵ from such position. Let us take ϵ equal to one degree, which, judging from figure 6 in Aveni's article, is a very conservative estimate. For instance, the direction towards Rigel passes more than 2 degrees from the center of the eastern structure. If N is small, the total area on the horizon, as defined by the stone positions and the acceptance angle, is $2\epsilon \cdot N!/2!(N-2)!$ and, therefore, the probability for any random point of the horizon to be aligned with 2 of the stones is

$$P = \binom{N}{2} \times 2\epsilon / 180.$$

For $N = 6$ positions on the circle, one finds $P = \epsilon/6$; for $N = 7$, $P = 0.23\epsilon$. The $N = 7$ case is probably an overestimate, because the boulder in the center causes some intervals on the horizon to overlap. In general, such overlapping becomes important for P larger than about 0.5, but here we can neglect this complication for the $N = 6$ case. Thus $P \sim 1/6$ to $1/3$. There are 10 stars brighter than 1^m (Aldebaran: $m_v = 0.85$) visible from Wyoming. Hence we expect that purely by chance $P \times 10 = 2$ or 3 such bright stars will be aligned, which is as observed by Eddy. Note that for a

uniform sky distribution, the density of rising points is not uniform but peaks in the east. Therefore the probability for alignments in the east is somewhat increased, but, in order to compute the expected number, we can use the average density. Of course the above does not mean that these bright stars were not considered when the Medicine Wheel was built, only that the number of alignments is indistinguishable from the expected one if the builders would not have bothered about stars at all. Therefore arguments in favor of the opposite have to come purely from other considerations. The reasoning quoted from Eddy (that the stars mark the time of good weather) is hardly "a tight argument." It is an amusing exercise for a cloudy night to take any random subset of 3 bright stars and then try to find *a posteriori* a common property of, or a trend defined by them. In this, one will almost always succeed. The statement that Aldebaran, Rigel and Sirius are rising in three consecutive months has therefore the same content of proof as the statement that those stars have marked different colors (red, blue and white, respectively). To be more specific: Rigel can be replaced by Capella (yellow) to form a triad with similar "properties." Yet no alignment with Capella is observed.

Apart from all this, it is not clear to me why the proposed alignments on stars are needed at all. A culture capable of knowing in detail the motions of the Sun and Moon in the sky would also be capable of knowing when the good and bad weather periods are due, without having to rely on the observations of particular stars.

References

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7/84

Quality of science teaching

As a physicist and recent chairman of the Board of Education of Howard County, Maryland, I was particularly interested in the article entitled "Leaving teaching: A difficult choice" by James E. Mowbray (*PHYSICS TODAY*, September 1983, page 36). Mowbray had been a very successful teacher in the Howard County school system and enjoyed the respect of his peers and his students. Many of the specific recommendations he made deserve careful consideration. Unfortunately, he misrepresented some elements of the problem in a way which may make an