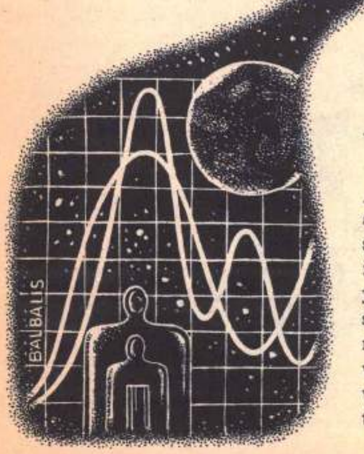
for your information



BY WILLY LEY

THE PUZZLE CALLED GEGENSCHEIN

PICK a really clear night, but not in June or July, or in December or January. If there is a moon in the sky it should be a sickle only; if the moon is full or nearly full you can give up before you started. Now if you have a clear night in one of the eight months where it can be done — and where there is no full moon — try to figure out where the sun

is at the moment. Then look at the spot in the sky precisely opposite to the position of the sun.

If, in addition to everything else, your night vision is good you'll see a patch of light, very faint light.

I have never succeeded myself (I keep trying, though) but the books say that this patch of light is roughly elliptical in shape, does not have a clear outline and that its largest diameter is three to four times the diameter of the moon. That is the *Gegenschein*. The name is German. Its English equivalent would be "counterglow" and up until a few days ago I thought that the "counter" part of the name refers to the fact that it is opposite the sun. Now, having waded through old accounts, it seems equally probable to me that the *Gegenschein* has its name because it is opposite to the zodiacal light.

As has been hinted by the list of provisions in the first paragraph the *Gegenschein* is so weak that it is drowned out by the light of the full moon. The reason why two months in winter and two months in summer are ruled out is that during those months the Milky Way covers the area of the *Gegenschein*. Even the Milky Way is more luminous than this patch of light.

The *Gegenschein* was discovered by — but here we run into the first complication. The *Gegenschein* seems to have about as many discoverers as the atmosphere of Venus which was first noticed either by the American Rittenhouse or else by the Russian Lomonóssov — with the fair probability that a note may turn up somewhere crediting somebody more than a century earlier.

HISTORIANS of astronomy are in fair agreement that the first discover of the *Gegenschein* was the German astronomer Theodor Brorsen. Brorsen, born in 1819 in the township of Norburg on the island of Alsen made his discovery in 1853 and published it the following year in a scientific journal under the title *Ueber eine neue Erscheinung am Zodiakallicht* ("On a new phenomenon of the zodiacal light"). But Brorsen himself stated that he was not the first to see it, and credits an observer with the name of Pézénas as having been the first to have seen it in 1730. What strikes me as strange is that it was not seen earlier.

When Giovanni Domenico Cassini was director of the Paris Observatory — from 1671 until near the end of his life in 1712 — he once spoke to his assistant

Niccolò Fatio about the zodiacal light and suggested that Fatio observe it as often as possible, which, in the temperate zone, is not very often. Fatio devoted several years to watching for the zodiacal light and wrote a treatise about his observations in 1886. It seems somewhat incredible that he should not have come across the *Gegenschein* but apparently he didn't; Brorsen was careful to check astronomical literature for forerunners of his own discovery.

Presumably because the *Gegenschein* is so hard to see nobody followed up on Brorsen's first report.

But twenty-two years later the *Gegenschein* was discovered again, this time by an Englishman, T. W. Backhouse. He lectured to the Royal Society about it. The paper was published in the *Monthly Notices* in 1876 under the title *On the aspect of the zodiacal light opposite the Sun.*

The third (or fourth, if you count Mr. Pézénas) discoverer of the *Gegenschein* was an American, Edward Emerson Barnard, whose eyesight seems to have had built-in amplifiers. He saw it one night in 1882 and thought that it was a very high thin cloud illuminated by starlight. But during the following night the "cloud" was still in the same place. Barnard who had not been brought up as an astronomer (he was originally a photographer) did not know about Brorsen's and Backhouse's earlier papers at the time. But he immediately concluded that this was an astronomical phenomenon.

Now if we agree on the definition that everything more than 200 miles from sea level is an astronomical phenomenon Barnard's conclusion is unassailable. Unfortunately this does not tell us what it is.

THE oldest explanation ties the *Gegenschein* to the zodiacal light, which appears as a slanting cone of light that can be seen (especially in the tropics) after sunset. If you watch in the morning before sunrise the same cone of light often precedes the rising of the sun. In fact, in the Near East, where some religious practices depend on the moment of sunrise, the zodiacal light had been noted down under names meaning "false dawn" as having no religious significance. (According to Alexander von Humboldt, in his *Kosmos*, vol. I., page 145 of the original edition, the inhabitants of Mexico knew the zodiacal light prior to 1500.)

Because of this shape its first systematic observer, Niccolò Fatio, concluded that the zodiacal light was actually an accumulation of dust particles in space, generally lens-shaped, its central plane more or less coinciding with the ecliptic, and illuminated by the sun. Fatio, and many others, thought that the diameter of this dust lens was less than the diameter of the earth's orbit.

Now, some astronomers said after the discovery of the *Gegenschein*, all we have to do is to assume that the dust lens, in an attenuated form, extends beyond the earth's orbit. Each dust particle would naturally behave like a tiny moon. Those particles closer to the sun than we are would turn their dark backsides to us and we could not see them. Those at the same distance from the sun as the earth would show a half-moon phase, but since there are not many of them we don't notice them. But those farther away would have "full phase", comparable to the full moon when it is farther from the sun than the earth. Those we see, as a very dim patch of light.

That the *Gegenschein* is always opposite to the sun is, therefore, easily explained. The laws of optics demand it; we see only those which, to us, are fully illuminated. And they are opposite the position of the sun.

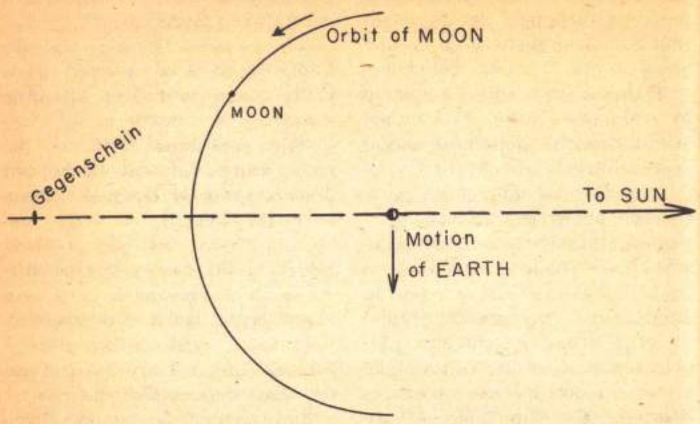
Barnard himself improved on this idea by pointing out that the earth's atmosphere should act as a lens and concentrate sunlight in that direction.

The reason why anybody bothered to think of additional explanations was that, as time went on, astronomers had less and less use for that much dust in space and found more and more reasons to doubt its existence.

BUT a little dust was permissible, hence the *Gegenschein* might be an isolated dust cloud.

It could be mathematically proved that a body located on the line connecting the center of the sun and the center of the earth would be dragged along by the earth, if it was located either somewhat closer to the sun or somewhat farther from the sun. There were just two conditions, in addition to the location on that line. One was a certain distance, 900,000 miles from the earth, if the body was farther away from the sun. The *Gegenschein* could be at just that distance. At any event one triangulation placed it a million miles from earth. The other condition was that the body to be dragged along had to have a very small mass as compared to the mass of the earth. Well, obviously a dust cloud would be virtually massless as compared to earth. (See Figure.)

In between, some other re-



Relative positions of Earth, Moon and Gegenschein. (Not to scale.)

searchers, for example Svante Arrhenius, pointed out that they had reasons to believe that our earth had a very tenuous tail, like a comet. And like a comet's tail it would point away from the sun. The *Gegenschein* was simply this tail, as it appeared to people looking from its origin along its length.

Still later—beginning in about 1937—Dr. Edward O. Hulburt, then one of the research directors at the Naval Research Laboratory, evolved another theory which has some similarity to the comet tail postulated by Arrhenius. It goes under the name of "atmospheric ion theory." It assumes a hairpin-shaped "veil" of ions around the earth, with the two "legs" of the hairpin pointing away from the sun. The light of the *Gegenschein*, according to this theory, is the end on view of the "legs" of the veil, much as thought by Arrhenius. The zodiacal light would be caused by the ions of the hairpin's bend, re-emitting solar energy as visible light.

In about 1949 the Russians began to feel that some modern work should be done on both zodiacal light and *Gegenschein*, and at the Gorna Astrophysical Observatory at Alma Ata they tried to take spectrograms of both. They succeeded in taking spectrograms, but these turned

out to be just somewhat more powerful versions of the lines that the night sky would produce anywhere.

The puzzle of the *Gegenschein* is still unsolved.

Could we do something with a space probe?

Well, if the old dust cloud theory is correct the answer is yes. But trying to shoot a rocket into the *Gegenschein* would be tricky indeed. Shooting "straight out" is an impossibility. What could be tried is to shoot past the moon when the moon is in about the position shown on the diagram. Then, if the rocket passes close enough (it might also have to be slowed down) the moon would deflect its path to the extent that the so-called "escape leg," after passing the moon, will point in the direction of the *Gegenschein*. Some additional guidance would certainly be needed. In fact, the whole shot looks too difficult for the immediate future.

But if we do get a space probe to go through the *Gegenschein* we would know what it is.

In the meantime I'll keep trying at least to see it.

The Annexation of Patagonia

HAVING been told by my readers that they like my column to be as far-ranging as possible, the virtually forgotten story of the "annexation" of Patagonia by the German Empire might prove to be amusing, especially since it has a scientific aspect.

The year was 1886, at the time when all the European powers grabbed colonies wherever they could. And the unwitting "hero" was Dr. Ludwig Brackebusch, professor of mineralogy at a university in Argentina, a native of Northeim in Germany and recipient of a Ph.D. from the nearby University of Göttingen.

The news first "broke" in a small newspaper which served both Northeim and Göttingen, the two townships interested in Dr. Brackebusch as a native son. The paper reported that Prof. Brackebusch—in a manner which was left completely unexplained—had annexed all the land to the south of 48° southern latitude and for some distance to the west of 54° western longitude, generally known as Patagonia. The article went on to say that the erection of a meteorological station at Cape Horn was being planned and that the newly annexed area should have some profitable aspects. To begin with, tobacco growing had just been undertaken there and was found to be very promising. And the land was thickly dotted with copses of a tree popularly known as the vinegar pear (scientific name: *Pirus communis* var. *acetosa).* While the fruit of this tree was unlikely to find a wide market, the wood would be welcome since it was just like mahogany.

That news of such far-reaching importance as the acquisition of a whole new colony should originate in an obscure provincial paper was explained by the bigger newspapers as presumably due to the fact that Prof. Brackebusch had first told this fact to members of his family. At any event a dozen other German newspapers reprinted the story, papers which were progressively more important.

Naturally the "news" was taken over by other newspapers, especially in England. A notice even made the *Times* in London. As for Prof. Brackebusch he was peacefully teaching mineralogy all along. Until, one day, he received a letter from the government of Argentina, firmly requesting his presence in Buenos Aires on a certain day and at a certain time. In Buenos Aires they considered Patagonia a part of Argentina and nobody was ready for a compromise of any sort.

Well, Brackebusch could prove that he had not been absent from the campus for long enough even to take a trip to Patagonia and the session ended with both head and handshaking. Fortunately it soon turned out that a group of graduates in Göttingen, after imbibing a sufficient quantity of beer, had written the original notice in the little paper. The storm blew over. Brackebusch, about a year later, called on them during a leave of absence, armed with specially printed calling cards reading

Prof. Dr. Ludwig Brackebusch
Protector of Patagonia

and in general nobody was harmed or mad for very long.

Oh, the scientific aspect of the story? Nobody—but nobody—had checked the coordinates on a map. The ocean there is probably two miles deep.

Mathematical Note on Seven-League Boots

IT was probably inevitable that somebody who recently saw me off at an airport, looking at the Boeing 707 jet waiting for me, remarked "Now you step into your seven-league boot and you'll be in New York in about five hours." This sounded like a nice literary remark at the time, but later, during the flight, I started to think in figures.

Part of it was due to the fact that I remembered a science fiction (or fantasy) story I had read more than 30 years ago. The story—it was of short novel length, and I seem to remember that it was of French origin although I wouldn't swear to it—began with the incident that a corpse is found on a country road. It is a corpse of a fairly young man, mangled and bruised and cut beyond description. Every bone in his body is broken and there is just enough left of his face to make a drawing for a public poster asking, "Has anybody seen this man recently?" The only thing which is not damaged are the high walking boots the man is wearing; they are new, Russian style, well made and in perfect condition.

A week or two later the wife of a dairy farmer reports to the police. Yes, she had seen the man, on the same day he was found dead. He had come asking for something to eat. She had given him something to eat and, seeing that his shoes were in an impossible condition, had given him the boots which had been around the house. When she turned around the man was gone, without even having said thank you. And the boots, the policeman wanted to know, did they belong to your husband? No, said the woman, we took them off a man my husband and the gendarme found dead in the forest a few years ago after the spring thaw. He could not be identified and he was in rags. But his boots were too new and too good to be buried with him.

The story is, of course, that the narrator then traced the indestructible boots backward until he had seven cases of dead bodies, all wearing new Russian style walking boots. And each corpse was found seven leagues from the place where the man had been given a new pair of boots by somebody who felt sorry for him.

Well, my modern seven-league boot, the 707 jet, was making about ten miles a minute at the time, flying high up in thin air to reduce aerodynamic drag. This was fast all right, but not yet as fast as the seven-league boots. At normal walking pace you make about three steps in two seconds. In sixty seconds you make, therefore, 90 steps. Wearing the seven-league boots you would cover 90 times 7 leagues. Since the league is usually defined as three statute miles, this means you would walk 630 miles per minute or 37,800 miles per hour.

Regretfully I had to conclude that the author of that partly remembered story (which was such a nice idea) had made a mistake. His conclusion was that the seven-league boots had been created by an evil magician to claim victim after victim. They would have done no such thing. The very first man to wear them, with his very first step, would not only have gone into orbit but would have acquired more than escape velocity and would have disappeared from this earth forever.

ANY QUESTIONS?

If I stood on another planet would the sky look different? Could I, for example, see the Southern Cross?

Dorothy Steinfeld
Elizabeth, N. J.

My first impulse, when I received this question, was to write at the bottom of the letter, "Yes, provided you look in the right direction," but then it occurred to me that this is a far more interesting point than it appears to be at the surface.

The general answer is, of course, that, as far as the so-called fixed stars are concerned, it does not make any difference whether you look up from the nightside of Mercury or from the surface of Neptune's larger moon, 2,760 million miles from Mercury. The major constellations will look alike from any planet in our solar system. It is true that the distance just mentioned would cause a minor shift for a few nearby stars, but that would not be enough to be perceptible to the naked eye. But otherwise the sky would look different from different planets.

Let's quickly run through the list. From the brightside of Mercury you wouldn't see anything. An eye adjusted to the sun glare of the brightside would not be capable of registering star images. From the nightside of Mercury you would see two really brilliant "stars" (Venus and Earth) but aside from them the picture of the sky would be the same as from Earth. From Venus, if you could look through its atmosphere, Earth would be the most brilliant star and Mercury would look much brighter than it does from Earth.

The sky as seen from Mars would be fairly different. To begin with you would have two evening (or morning) stars, Venus and Earth, with the Earth much the brighter of the two. Then you would have another very bright star, nearly motionless, namely the outer moon of Mars, Deimos. The inner moon, Phobos, would provide most of the entertainment. It would rise in the West and climb to its zenith in 2 hours and 9 minutes, increasing visibly in size and also changing its phases in the process. When at its zenith, twice

out of three times, it would wink out, eclipsed by the planet's shadow.

The view from one of the moons of Jupiter would again be much different. Of course, the masive planet would be the dominant object in the sky. If you were on one of the smaller moons of Jupiter the four large moons would be interesting sights, too. The Sun would have only about 1/5th the apparent diameter as compared with the view from Earth, still showing a small disk of incredible brilliance. The other small moons of Jupiter would not be visible to the naked eye. Of the inner planets, Venus and Earth should be visible quite close to the sun. It is very likely that the two clusters of the "Trojans"—the small groups of asteroids in Jupiter's orbit, 60 degrees ahead of and behind the planet —could be seen. Since the eye very likely would not be able to tell the several bodies apart they might look somewhat diffuse. And at times the brightest planet in the sky would be Saturn, naturally.

The sky as seen from one of Saturn's moons is again something different. Again the planet would be the dominant object in the sky. Since all of Saturn's moons are fairly large, the other eight should be visible from any of the nine. The sun would be down to one-tenth of the size to which we are used but still would shed a large amount of light. Jupiter would be the most brilliant planet in the sky. The inner planets would no longer be naked-eye objects. Of course if Saturn and Uranus are in the same sector of their respective orbits, Uranus would also be a very bright planet. Naturally Neptune, if in the proper sector of its orbit, would be a naked-eye object.

From one of the moons of Uranus the sky would be mostly the sky of the fixed stars. Of course the other moons of Uranus would be clearly visible. Of the planets, Jupiter, Saturn and Neptune would be naked-eye objects. But Neptune would put in an appearance only several centuries apart, Jupiter would appear to be close to the sun (and the sun would just be a brilliant star) so that the planet that could be seen much of the time would be Saturn — with disappearances amounting to about a dozen Earth years. And from Neptune's larger moon you would see the fixed stars, a brilliant star (the sun), the smaller moon of Neptune on frequent occasions and for long periods not a single one of the other planets.

But from each planet—especially if you had a pair of binoculars to help you — the appearance of the constellations would be typical enough so that one hour of observation would tell you where you are.

Why is a division by zero undefined? If you answer that it is undefined by definition (paradox?) why doesn't somebody define it?

Charles T. Warren
West Chester, Penna.

This is a question which requires two answers, and I don't think that two answers to one question is too paradoxical. The first answer is that mathematicians, like lawyers and judges, do not always use the Queen's English the way other people do. Mathematicians will say, without batting an eyelash, that the "trivial divisors" are naturally ruled out and that they expect a "unique" solution to this problem. But a "trivial divisor" just means either the figure itself or else "one," while a unique solution is not an unusual one but merely means that there is only one solution.

Now for the "undefined" division.

You realize easily that multiplying a figure by zero will always result in zero—because the request to multiply 5, or 57 or 457 by zero is a request not to multiply it at all, not even once. Now if you tried to divide by zero you would have the following: The figure M is to be divided by N, with X as the result. Logically, then, N times X must equal M. Now let us assume that $N = O$ so that you divide M by zero and start looking for the value of X, assuming, naturally, that M is a figure other than zero.

The equation N times $X = M$ now has turned into zero times $X = M$. But zero times X is zero, hence M would have to be zero too which makes the whole operation nonsense because this produces $X = 0/0$.

Going over the procedure once more slowly, you'll realize that you either find that X just doesn't have any logical value, or else you find that zero times X equals zero—which we knew all along. Hence, some mathematicians call this operation "undefined," with the meaning that it doesn't yield a result. Other mathematicians feel more strongly about it and have added a commandment saying, "Thou shalt not divide by zero."

— WILLY LEY