What would even a professor of Physics do without our Albert?

The Higher Mathematics

by M. C. WOODHOUSE

ALBERT stood in the little room behind the lecture theatre, watching the sudents file in and take their seats. He took a personal interest in the attendance sheet for every lecture given in the Department of Physics, and it gratified him to see that, this morning at any rate, the benches would be filled. He had worked for two hours before breakfast, making sure that today's demonstration would run without a hitch, and so he listened to the hum and chatter which preceded the Professor's entrance with a growing content.

The post of Chief Technical Assistant to the Physical Laboratory was one that carried grave responsibilities. For, just as a college at a University is run, not by the Master or the Senior Tutor, but by Alf, the Head Porter, so the smooth running of a Scientific Department rests in the hands, not of the Professor or his assistants, but of men like Albert and his staff, down to the boy who washes the flasks and test tubes. Lecturers may come, and lecturers may go, but Albert stays on for ever.

The lecture was due to start at any moment. Nine o'clock, said the notice on the board outside, and it was nearly ten past now. The daily battle to see which would arrive the later, the lecturer or the last ten of his audience, would soon be decided, and Albert could retire to the laboratory until the end of the lecture.

The door at the far end of the room swung open, and the Professor of Physics came in. The front rows of the audience, containing the keener members of his own class, together with those senior members of other departments who had been in-

vited to attend his lecture, turned from the study of the apparatus that filled nearly all of the rostrum, towering high on either side with banks of dials and cathode-ray tubes, to greet his entrance. The white wall of daily newspapers that hid the back rows fluttered in unison and dropped momentarily, to be lifted again more discreetly.

Albert quitted his post, and the lecture began.

"This morning," said the Professor, apparently addressing the projector in the centre of the audience, eight rows back, "I am going to demonstrate an impossible experiment to you."

If he had hoped to get a reaction from his listeners, he was disappointed. A few polite smiles from those nearest to him were all that greeted his opening statement. He continued:

"It concerns a branch of applied mathematics with which you are all familiar to a greater or lesser degree; a branch which has been given the name of Topology."

An earnest-looking student in the front row twisted a strip of mauve blotting paper into the form of a Moebius band, in an absent-minded fashion. The remainder of the audience was by now beginning to detect a pleased ring in his voice, and a number of those in the centre rows put down their crosswords and prepared to listen with more or less attention.

"As you see," he went on, "the demonstration apparatus is fairly complex. On my right"—he waved in the direction of an assembly of wires and enamelled boxes—"you will see the power supply to a pair of plates, one of which is imbedded in the floor directly in front of me, and the other in the ceiling above."

He pointed with a piece of chalk, and about half of the audience followed the gesture. The plates were about three feet square, made of copper, and slightly hollowed towards their centres.

"When the power supply is switched on, there is formed between the plates, as you can readily imagine, an electrical field of no little strength."

Here, a number of the occupants of the back rows put down their papers, too. The possibility of electrocution may have entered their heads. In any case, the old boy sounded more promising than usual. The Professor crossed to the blackboard.

"Let us, for the moment, reconsider some of the theory that I have endeavoured to put before you during the course of my last two lectures. We have seen that the evidence obtained from counting the number of visible stars suggests that the universe, or space, as it is popularly termed, possesses a negative curvature, rather as the back of a saddle is curved. I shall not bother to run over the mathematical derivation of this finding again, since those of you who were here last time will, I hope, have followed the argument quite easily.

"We also saw that, as a result of this negative curvature, the volume of space within a given radius from any point of reference is greater than would be the case if the space were uncurved."

Shifting his attention from the projector, the Professor perceived a glazed appearance about the eyes to left and to right. It was, he supposed, possible that some of his pupils had not taken the trouble to read the textbooks that he had recommended for study during the term. Should he repeat his explanation for the benefit of the glassy-eyed, or assume that all was well and proceed to the next point? He compromised.

"I will ask you to accept, then, that if the space in a given region is negatively curved, then the real volume of that space will be larger than its apparent volume. Conversely, if the space is positively curved, then its real volume will be less than it appears to be."

Perhaps a little joke might establish *rapport* with his audience?

"If you buy a pint bottle of beer, you want to specify that the space inside the bottle is negatively curved, not positively."

It fell flatter than a two-dimensional pancake. He hurried on.

"It follows, then, that if we could arrange for the space within a container to possess an *infinite* negative curvature, then the real volume of that container would necessarily be infinite. This, ladies and gentlemen, is precisely what I have done, and what I hope to demonstrate to you this morning."

The scales could practically be heard falling from the eyes of the occupants of all the rows, front, middle, and back. The nervous student with the Moebius blotting paper tore it

into small pieces, littering the floor.

"To return, then, to our apparatus. I have explained that the portion on the right is devoted to the supply of power to the plates, between which there is formed an electrical field. On the left, you will see three small parabolic reflectors, all of which are focused on the same spot, about three feet from floor level and in the field between the plates. I will not bore you with the details of the construction of the apparatus which feeds energy to these reflectors. It is enough to say that, when they are all focused on this spot, the combined effect of the electrical field forces and the output from the reflectors is so to rearrange the lines of stress within the region as to render the space it contains infinitely curved in a negative sense. The implications of this I have already explained to you. Are there any questions so far?"

The earnest student rose.

"Do you mean to say, then, Sir, that you propose to create an apparently small region whose real volume is in fact infinite?"

"You grasp my meaning admirably."

"I don't believe it."

"Naturally, my young friend, you don't believe it. Nevertheless, I hope to prove to you that it is true."

"Get on with it, then," said an unidentifiable voice from the back of the hall. This was followed by a certain amount of stamping of feet and banging of books on benches.

The Professor switched on the right hand collection of apparatus. Carefully avoiding the copper plate in the floor, he crossed to the other side of the room and adjusted a number of dials, then turned to face the audience.

"Are we ready, then?"

Opinion in the room was divided. Hardly anyone thought that the Professor was actually going to get the result he claimed. Some, however, couldn't see why he should bother to give a demonstration if he thought he wasn't going to get it. A few had a mental picture of his pouring a never-ending stream of light ale into or out of a region in space. Most were slightly apprehensive.

The Professor depressed three switches in rapid succession. Nothing whatever happened.

After about ten seconds,

the unidentifiable voice spoke again. "Good stuff," it said.

The Professor stepped forward and addressed himself to the voice.

"Just what did you expect to happen?" he enquired. "Flashes of green lightning, no doubt, or a weird violet glow? How do you think a region of negatively curved space manifests itself? You cannot see the field around a magnet, yet it is there just the same. However, if one of you will be so kind as to switch on the projector, perhaps you may see something, since light rays will be distorted in passing through the region."

After a moment, the projector came on. The beam of light shone on the wall behind the Professor's region of curved space, and in the centre of the square of light appeared a vague silhouette, shapeless, refractory, like the shadow of the heat ripples above a brazier.

The Professor picked up a piece of chalk and lobbed it towards the copper plate in the floor. It travelled in a high curve, fell towards the plate, and vanished about three feet above floor level.

There was a short silence. Then the voice from the back of the hall said: "Good stuff," again, but this time with quite a different tone to the statement.

The Professor picked up the blackboard eraser and threw that, too. Three feet from the floor, it disappeared. A box of matches and a handkerchief, rolled into a ball, followed.

In the middle of the hall, a student stood up. His comment was brief and to the point.

"Roll up your sleeves."

"I beg your pardon?"

"I said, roll up your sleeves, please, sir. I just don't believe it, that's all. It's quite impossible."

"I can quite understand your confusion. I suppose, to the lay mind, this experiment must be quite impossible to understand. Perhaps you would care to come down before the class and test it for yourself?"

"Well, I . . ." Then, with a note of truculence: "Very well, then."

After some scuffling, the student reached the front of the room.

"May I have your name, please?"

"Layton."

"Very well, Mr. Layton. Perhaps you would select an

object with which to test the properties of space with in-infinite negative curvature. Since you are so confirmed a sceptic, your watch?"

The student considered for a while. Then, impatiently, he pulled off his watch, and, muttering something uncomplimentary about the supposed properties of curved space, he tossed it towards the plate. Three feet from the floor, it vanished.

He looked at the Professor, who was standing with the smile of the successful conjurer on his face.

"Mass hypnosis," he said.

"Oh, come now, Mr. Layton. Surely you don't think I have come here to demonstrate a new version of the Indian rope trick?"

He shouldn't have mentioned it. The student's action was swift and startling. He took a short run, as though along a springboard at a swimming pool, launched himself into the air in a neat jack-knife, and dived headfirst into nothingness. Those who saw him go observed that he did so from the tips of his fingers to the soles of his feet. It was the cleanest dive that had ever been witnessed in the lecture theatre. Straight into infinity, without a splash, and fully clothed, too.

Sitting in the laboratory office, Albert sipped his cup of tea and listened with approval to the noise coming from the theatre. A noisy lecture was usually a good one.

That meant that his work on the Professor's apparatus was being justified. Not that he knew what it was all for: the Professor had been much too secretive about it. But perhaps he would get a private word of congratulation after the lecture was over, just to show that the Professor appreciated that the work of the Department depended on the workshop and laboratory staff.

And if there should be a hitch, which was most unlikely, then Albert would appear at the door like a Slave of the Lamp, to get things under control again.

He smiled, and took another sip of tea.

It was, perhaps, just as well that he was not in the hall to watch what was going on there, or he would have been rudely surprised.

The Professor and two students had tied a number of scarves together to form a

rope, and were paying it out, hand over hand, into a patch of negatively curved space three feet from the floor. Opinion as to the value of this manœuvre was once again divided, some maintaining that so long as he stayed near the entrance, he might be able to get hold of the knotted scarves and draw himself out again, while others, among them the earnest student with the Moebius band, held there was no such thing as a specific entrance to infinity, and that, therefore, they were wasting their time.

The truth of this argument was not disputed, but, on pulling on the end of the rope, the portion which had just vanished reappeared again, so it was felt that there was some hope.

There are some people who must prove their point, however, and the earnest student was one of them. He proved this most successfully by crawling under the infinity patch and standing up rather suddenly, the suddenness being due to the considerable charge on the copper plate in the floor. They didn't quite catch his feet as he disappeared.

One of the more irreverent of the bystanders wrote: "Score—Two - nil" on the board, and the infinity fishermen paid out some more rope. If there are some people who must always prove their point, there are others who will not accept a point even when it has been proved.

A Physiologist wanted to know whether the air in an infinite volume of negatively curved space would support life.

"There isn't any air," said the Professor.

The fishermen stopped paying out scarves, discouraged.

"If there isn't any air," said the Physiologist, "then there must be a vacuum. And if there's a vacuum, why isn't the air from this room being sucked in?"

"Must be self-sealing, like an aeroplane petrol tank," said an Applied Physicist.

"I think," said the Professor, "that you are all confusing the practical with the theoretical issues. This is not a case of crawling through a manhole into infinity, you know. The volume of the region in question is only theoretically infinite. If it were practically so, there would be no room for us on the outside of it, would there?"

He looked around with the

air of one who has proved his case beyond argument. The Physiologist, however, remained unsatisfied.

"That takes a load off my mind, I must say. You mean those two have only theoretically vanished into a mathematical infinity? Perhaps you'd better let down a whole string of mathematical equations and see if they can climb back up that. I just don't know what we'd do without you Physicists."

"There is no need to be offensive," said the Professor. "I shall go down—I mean in—myself, and try the air. You shall tie the scarves round my waist and let me explore, and if I pull on the end of the line you can haul me in."

This proposal was hailed with approval, a number of those present expressing a wish to go instead, out of curiosity. The end of the rope of scarves was tied to the Professor's belt, and a chair was brought and placed next to the copper plate. The Professor mounted, held his nose with one hand, and jumped, while the Physiologist and four others held the other end of the rope.

It broke at one of the knots. Score—three - nil.

"You know, he was right in a way," said the Applied Physicist. "In a sense, they *have* only theoretically vanished into a mathematical infinity, because the concept of infinite volume, as applied to that particular region, refers only to the three-dimensional framework we are using at the moment."

"Oh, I see. Fourth-dimensional stuff, eh?" said the Physiologist. "You mean they might have plenty of air after all, only in another set of dimensions, a sort of parallel space-time continuum? It's a thought, I suppose. Is it worth betting on?"

"I think so. Look, I'll tell you what we'll do. We'll only use one scarf, a long one, and tie one end to a bench. Then, one of us will take hold of it and slide; not jump, into that patch, and the others can follow, holding onto each other all the time, so that we never lose contact with the place we came in. That way, we'll have a very long human chain, and so long as nobody lets go, we'll all be safe, and all of us will see what goes on inside there. Myself, I'm pretty curious about what they found."

So were they all.

Albert, hearing the sound of voices dying away into silence, and the scrape of chairs on the floor, put down his third cup of tea. The lecture must have about finished by now, and the Professor would probably need him to dismantle the apparatus and clear it out of the room.

He went to the door of the lecture theatre, and listened. Not a sound. He pushed it open a fraction, and peered round it. Not a person in the room, not even the Professor.

He pushed the door right open and went in. The exit doors were still shut. Books lay on all the benches. He walked over to the blackboard, and stopped in front of the apparatus.

On the floor, one end tied to a bench, was a scarf. It sloped up into the air, stretched taut, as though it were hanging over a cliff edge, supporting a weight. But there was no edge visible, and the other end of the scarf was missing. It shifted slightly, and stretched a little more.

"Blimey," said Albert.

He untied the end from the bench. Like lightning, the scarf whipped across the floor and into the air, and vanished.

"Liver," said Albert. "Must be."

They'd left the apparatus switched on, wherever they'd gone. He went over and switched it off. First the power supply to the right, then the three reflectors on the left.

"Impractical, that's what," said Albert. "No telling what they'd do to themselves if it wasn't for me, is there?"
