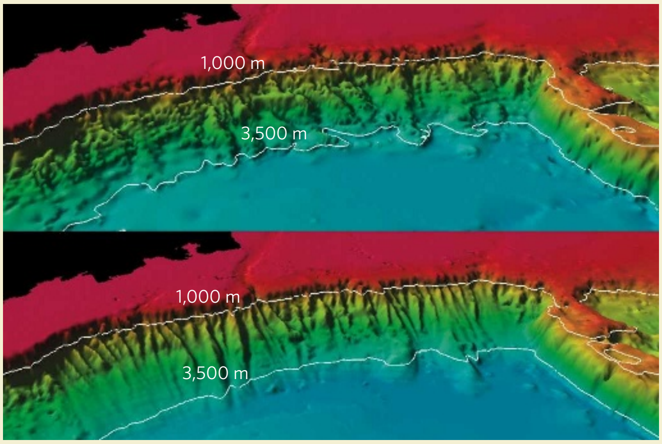
OCEANOGRAPHY

Bottom of the top of the world



The floor of the Arctic Ocean comes into sharper focus with the publication of an improved version of a bathymetric chart first released in provisional form in 1999, and as version 1 in 2001. Accurate mapping of the ocean bottom is essential for modelling deep ocean circulation, but also has a political angle in defining the extent of the continental shelf — a serious consideration in such a politically sensitive part of the world as the Arctic.

The story behind the improved bathymetric chart — IBCAO Version 2.0 — is told by Martin Jakobsson and colleagues in *Geophysical Research Letters* (M. Jakobsson *et al. Geophys. Res. Lett.* **35,** L07602; 2008). Its production is an instructive case of new data being married to a reinterpretation of old.

Most of the new data come from mapping missions carried out since 2000 with multibeam sonar equipment aboard various vessels, including USCGC *Healy*, RV *Polarstern* and IB *Oden*. Multibeam sonar systems differ from the sidescan systems used, for example, to look at the shape of the sea floor or to detect wrecks, in providing information mainly about depth.

The more dramatic changes to version 2 over version 1 are that, as the authors laconically put it, the "deep abyssal plains are systematically ca. 50–60 m deeper ...". The revision stems from a metadata analysis of records collected by US Navy submarines over several decades, which are a central source of bathymetric information at high northern latitudes in particular. Conversion of data for version 1 was based on an assumption that the figure for the speed of sound in water used for the original calculations was 1,500 m s^{-1}. But in many cases the figure applied was 1,463 m s^{-1}. Hence the change in estimated depth, which also helps to explain several anomalies evident in version 1.

The three-dimensional views shown here are depictions of the Alaskan Slope and Northwind Ridge before (upper image) and after Jakobsson and colleagues' exercise in producing version 2. The image is about 650 km across, and the black area at the upper left is Alaska; the Northwind Ridge is the 'peninsula' on the right. The improved definition is evident in the sharper depiction of the gullies, caused by erosion, that scar the Alaskan Slope.

The new map is far from the final word. The authors point out that a near-perfect bathymetric model will require comprehensive multibeam coverage, which won't be available anytime soon. Meanwhile, more details on version 2 and derivations of it are available from www.ibcao.org.

Tim Lincoln

ASTROPHYSICS

Exhaust inspection

David L. Meier

What do you see if you peer into the exhaust of a jet engine larger than our Solar System? Only astronomers with the largest radio telescopes can see the full picture — and definitive observations are beginning to filter through.

Cosmic jets — enormously energetic, highly directed beams of charged particles — can be ejected by stars as they form[1], as they die[2–4], and even, in certain instances, as they are reborn, rekindled by the accretion of surrounding gas[5,6]. The energy carried away by a jet can help to bring a dying massive star to explosion in a supernova, or disperse a less massive one as a planetary nebula. Jets provide some of the heating of the gas between stars, and can even disrupt the intergalactic medium in galaxy clusters.

Despite a profusion of hypotheses for how these cosmic power generators work, astronomers still don't have a clinching theory, largely because of a dearth of observations with which to compare models. New findings from Marscher *et al.* (page 966 of this issue)[7] go a long way to redressing this imbalance. The authors report how, in unprecedented detail, they imaged a jet engine belching out a puff of exhaust, allowing real-time insight into how jets work.

Theories exploring the role of gas accretion in jet acceleration originated in the late 1970s and early 1980s[8–10], and have more recently been extended to take account of features such as flows at close to the speed of light and the very hot temperatures of the jet plasma[11]. Many of the jet-forming objects are dense, accreting agglomerations of matter such as neutron stars or black holes, both of which originate from failed stars. But jets are also produced by objects such as fading 'white dwarf' stars, or even stars such as the Sun when they are first born. Understanding jet emission from one type of these objects, therefore, might lead to an understanding of many others.

The favoured picture that has emerged is of a mechanism similar to the operation of a fighter plane's jet engine, but confined within the lines of a strong magnetic field rather than a steel casing. Rotation of the magnetosphere around the central object creates a stiff, helical field that acts as both a turbine and a nozzle, expelling the exhaust flow and collimating it into a narrow beam (see Fig. 3 on page 968). Far from the object, this natural pinching action can overcollimate the beam, so that it starts to converge. The point of maximum convergence is known as the modified magnetohydrodynamic fast point; beyond that point, the jet can produce a strong 'fast-mode' shock wave that can distort or destroy the well-ordered structure of the magnetic nozzle. Other, less dramatic, 'slow-mode' shocks — pressure waves that travel parallel to the twisting field lines and do not disrupt them — can develop before the flow reaches the modified fast point.

The equations governing these processes are very complex, and several simplifying assumptions are needed to solve them. For that reason, the whole picture of magnetic jet acceleration just sketched is still a matter of debate. Marscher *et al.*[7] are the first to test the picture observationally. Their results, at least partially, confirm the model.

The authors' test-bed was the notoriously unruly BL Lacertae, the archetype of a particularly extreme form of jet emitter known as a blazar. BL Lacertae is an active galaxy containing a central supermassive black hole, and produces a jet with a speed 99% that of light. The jet, to within 10°, is pointing directly at us, so that looking down into the jet nozzle allows Earth-bound observers to examine the engine's inner workings directly.

This particular jet emits enormous amounts of energy at radio frequencies, and is huge — about two light years across. So, despite its immense distance from us (about 900 million light years), its angular size seen from Earth is fairly large, at around 0.5 milliarcseconds (one arcsecond is 1/3,600th of a degree). Regular stellar jet engines in our Galaxy might be much closer, but they are diminutive by comparison, just nanoarcseconds in size. The jet from BL Lacertae was big enough for Marscher *et al.* to exploit a technique known as very-long-baseline interferometry (VLBI), which uses radio telescopes scattered around Earth's surface to create essentially one big radio telescope. In this case, these were the ten telescopes of the National Radio Astronomy Observatory's Very Long Baseline Array (VLBA), situated across the United States. Using this technique, the authors could make images of the jet with an angular resolution of about 0.1 milliarcseconds.

The VLBI technique, coupled with γ-ray, X-ray and optical-wavelength observations, allowed the authors to observe what happened as BL Lacertae sent a new pulse of plasma down its jet nozzle (see Fig. 1 on page 966). During the period of observation, the source twice sent out a flare of very-high-energy γ-rays. The first event looked very much like a slow-mode shock wave, tracing the plasma pulse as it travelled around one coil of the helical magnetic field. The field would thus seem to be well ordered up to that point, as predicted by theoretical models.

The second γ-ray flare coincided with a strong brightening of the radio 'core'; by this time, the pulse had probably left the magnetic nozzle and was passing through the strong fast-mode shock. Unfortunately, measurement limitations mean that we cannot be certain whether the magnetic field was helical or disordered in this core region during the second flare, although the strengthening and weakening of the radio polarization during and after the flare points to the second option. In that case, the fast-mode shock seems to have at least partially disrupted the helical field structure. Thus, despite the relative simplicity of the theoretical models, many of their predictions seem borne out by observations. This confirmation of the theoretical understanding of systems containing supermassive black holes increases the likelihood that jets of all sizes and types work in a similar way.

At present, jet acceleration from any cosmic object can be imaged only using the technique of VLBI at radio wavelengths. Observations at γ-ray wavelengths alone create the impression that flares may be produced within one-thousandth of a light year of a central black hole, but these latest observations[7] indicate that they occur more than a light year away. Thus, when NASA's γ-ray Large Area Space Telescope GLAST, which is due to launch on 16 May, starts to deliver jet measurements, it will need VLBI co-observations to deliver a complete picture. Japan's new VSOP-2 satellite will increase the radio imaging resolution of jets such as that of BL Lacertae by at least a factor of three, but to complete much of its proposed work it will need instruments such as the VLBA to supply detailed interferometry images[12]. Unfortunately, VLBI instruments are currently facing a funding gap that could see them scaled back or closed. The results of Marscher *et al.*[7] underscore how vital these instruments are to the understanding of jet acceleration throughout the Universe. ■

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GENE TRANSCRIPTION

Two worlds merged

David M. Lonard and Bert W. O'Malley

Why would two distant genes — on separate chromosomes and from different nuclear locations — unite in response to signals for gene expression? They might be seeds for the formation of transcriptional hubs.

Gene transcription occurs largely at the submicroscopic scale. So although microscopic analysis of nuclear architecture has implicated various structures in this process[1], it has lacked the power to unravel the role that higher-order organization of chromatin (complexes of DNA and histone proteins) has in the expression of individual genes. Consequently, it has been difficult to combine whole-cell approaches such as microscopy with the molecular and biochemical techniques[2] that are primarily used to study gene expression. Fortunately, technological advances in both microscopy and molecular approaches are closing this gap. For instance, writing in *Cell*, Nunez *et al.*[3] bring a refreshing concordance between these two types of method to show that gene expression associated with activation of the nuclear receptor ERα (oestrogen receptor-α) depends in part on a large-scale reorganization of the genome that involves interactions both within and between chromosomes.

Much of the recent progress in understanding how gene transcription factors interact with chromatin can be credited to 'ChIP-on-chip' technology[4]. For example, this method revealed that ERα interacts with a specific set of DNA sequences known as oestrogen-response elements[5] (EREs), and that only some of these interactions enhance transcription. Other transcription-factor binding sites adjacent to EREs also seem to function cooperatively in facilitating transcription, indicating that various non-coding DNA sequences influence gene expression[5].

For their analysis of chromatin reorganization in response to the activation of ERα transcription, Nunez *et al.* used many sophisticated approaches, one of which — chromatin-conformation capture — is also related to ChIP-on-chip. This technique allows the detection of long-range interactions between genes, even those on different chromosomes[6]. Specifically, the authors aimed to characterize the interaction between two genes regulated by the oestrogen hormone: *TFF1* on chromosome 21 and *GREB1* on chromosome 2. They find that, in response to hormone treatment, the chromosomal regions (loci) containing these genes physically reach out for each other.

Nunez and colleagues also find that genes at other oestrogen-regulated loci interact with each other, indicating that interchromatin pairing of DNA sequences is a common feature of ERα-mediated transcription. What's more, previous work using another approach — assessing the effect that restricting genes' movement within the nucleus has on their transcription — has shown that other functionally related genes, such as those with roles in immunity or cellular differentiation, also make interchromatin contacts[3]. So it seems that interchromatin interactions are not restricted to a particular cellular process.

Interchromatin contact between *TFF1* and *GREB1* depends on the binding of ERα to an ERE. Moreover, these interactions are also influenced by the activity of other proteins, including chromatin remodelling factors and proteins that bind to the cytoskeletal protein actin; this indicates that passive movement is not sufficient for chromosomal reorganization[1]. Nunez *et al.*[3] add to the list of proteins known to mediate interchromatin interactions, showing that transcriptional coactivators such as SRC-3/AIB1, CBP, p300 and PBP are also involved in this process. Furthermore, they show that another co-regulatory protein — the