ionisation is then especially remarkable, but we must then ascribe to chance the fact that the intervening material happens to be at a redshift so near to the emission redshift.

We now consider the possibility that a gravitational lens is operating. The theory of gravitational imaging in a cosmological context has been considered elsewhere (see ref. 6 and refs therein) and we simply quote the main results of applying this theory. The following are the relevant parameters involved in considering the gravitational lens hypothesis: the angular separation of the images, the shape of the images and their sizes, and the amplification of the two images. There is no evidence on the plate taken on 2 April or on the POSS for any departure of the images from stellar images. The magnitude difference between A and B (Table 1) is ~0.3. mag and this is confirmed by our observations.

The 0.3 mag difference between the two components requires that the amplification of QSO light is ~4 for the brighter image, and thus implies a normal luminosity for the QSO. (This is also suggested by the absence of a strong narrow component in the C IV emission which might be expected if the source were a strongly amplified Seyfert nucleus.) The maximum angular size of the lens is only ~8 times that of the object, so we should not expect to resolve it on the sky.

If the matter responsible for the gravitational imaging is far from the QSO, then, from simple euclidean space calculations we estimate that at redshift z_L its mass must be $\sim 10^{13} z_L M_\odot$, and require that it be contained in a radius $\leqslant 30$ kpc. If a galaxy is the cause, then a lower limit of $z_L \sim 0.1$ is likely from its absence on our plate material. However, the centre of such a galaxy must be within ~0.5 arc s of the direct line between the QSO and the observer. The chance of finding such an alignment with a massive elliptical galaxy obtained by folding in our mass requirement with Schechter's[7] luminosity function (with a mass-to-light ratio of 30) is roughly 10^{-5}, although the precise number depends quite strongly on the magnitude differences and angular separations allowed. Thus, while such coincidences must be very rare, it is not out of the question that we should have one example in the ~1,000 QSOs known.

An apparent objection arises from the difference in the shapes of the continua between the two QSOs. It is possible that differential reddening along the two light paths may be responsible. Note that the observed break at 5,300 Å corresponds to an emitted wavelength of 2,200 Å in the rest system of the QSOs. This is the wavelength of a well known resonance in interstellar extinction by dust in our Galaxy, and a model can be constructed to explain the observed continuum ratio incorporating the 2,200 Å feature at the redshift of the QSOs. This would imply that the intrinsic flux from B exceeds that from A.

Further observations would shed light on the gravitational lens hypothesis. If the flux from the object is variable, the light curves of the two images should be similar but with a relative time delay due to the difference in path lengths. The lag depends on the details of the geometry, but with the parameters discussed above would be expected to be of the order of months to years. Determination of the radio structure would also clearly be of great value.

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Since submission of this article we have heard that on 19, 20, and 21 April the two QSOs were observed by N. Carleton, F. Chaffee and M. Davis (of the Smithsonian Astrophysical Observatory) and R.J.W. using the SAO photon-counting reticon spectrograph attached to the SAO–UA multiple mirror telescope. The observations covered the range 5,900–7,100 Å with a resolution of 4 Å FWHM. Details will be reported elsewhere, but the main results are: (1) to within the measuring errors the Mg II emission lines have the same profiles and observed equivalent widths (85 and 76±12 Å for A and B respectively) and the same redshift (1.4136±0.0015 for both). (2) Absorption lines due to Fe II λλ2586, 2599, Mg II λλ2795, 2802 and Mg I λ2852 are present in both objects but are somewhat stronger in A. The mean heliocentric redshifts of the two absorption systems are 1.3915 for A and 1.3914 for B. A cross-correlation analysis confirms that the difference in the two adsorption redshifts is remarkably small and corresponds to a velocity difference of $7\pm10 \text{ km s}^{-1}$. These observations strengthen the case for a gravitational lens.

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The moving emission features in SS433 require a dynamical interpretation

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New spectrophotometry of SS433 shows that the variable-wavelength emission features discovered by Margon et al. are due to the simultaneous presence of material having a substantial redshift and a substantial blueshift. A magnetic interpretation for the features is also ruled out by polarimetric measurements. Implications for dynamical models are discussed.

STEPHENSON–SANDULEAK 433 is an emission line object which has recently been identified as the optical counterpart of the X-ray source A1909+04 (ref. 1) and has been associated with a compact radio source and the supernova remnant W50 (refs 2–4). However, the discovery by Margon *et al.*[5] of the highly variable-wavelength emission lines has sparked intense interest in this object. Margon *et al.* found several broad, unidentified emission features which showed daily changes in intensity, profile and wavelength, with positional changes of up

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to 600 Å in 30 d. Their comprehensive analysis showed SS433 to be quite distant ($\geqslant$3.5 kpc), luminous ($M_v \leqslant -3.5$), and completely stellar in appearance. Furthermore, there were strong H, He I, He II and C III–N III emission lines near rest wavelengths, indicating that the object must be relatively nearby if extragalactic. Margon *et al.* reached no conclusion as to the basic cause of the wavelength shifts for the unidentified emission lines. Accordingly, we have recently obtained spectropolarimetric and further spectrophotometric data on of SS433 to determine whether the features might be due to velocity or magnetic Zeeman shifts.

Circular spectropolarimetry

We considered the possibility that a magnetic field $>10^8$ G might be capable of providing highly variable Hα Zeeman emission components at the wavelengths of the observed 'red' and 'infrared' features described by Margon *et al.* This idea was supported by the recent identifications of a strong π component near λ5850 and weaker σ components near λ7000 in the photospheric spectrum of the magnetic white dwarf Grw + 70°8247 (J.R.P.A., H. S. Stockman, E.K.H. and J.L., unpublished). According to the theory, the 'infrared' feature in SS433, which has previously been seen[5] in the range 7,000–7,600 Å, would be expected to show a strong circular polarisation signature even if the continuum polarisation proved to be much weaker. This hypothesis can be tested by circular spectropolarimetry.

Table 1 Identifications and velocity shifts of 'moving' features in SS433 scans

Date/instrument	Feature (Å)	Suggested identification	Redshift
2 December 1978	5300:(Å)	He I 5876	−0.098:
2.3-m	5816	C IV rest?	—
	5945	H 6563	−0.0942
	6054	He I 6678	−0.0934
	7600:	H 6563	+0.158
3 December 1978	5300: (5283::)	He I 5876	−0.098:(−0.10)
2.3-m (1.3-m)	5684 (5671:)	H 4681	+0.1693 (0.166:)
	5808 (5817:)	C IV rest?	—
	5914 (5922)	H 6563	−0.0988 (−0.0976)
	6834:(6848::)	He I 5876	+0.163:(+0.165::)
	7630:(7600+)	H 6563	+0.1626(−)
27 February 1979	4505:	H 4340	+0.0380
2.3-m	5045	H 4861	+0.0378
	5810	C IV rest?	—
	6100	He I 5876	+0.0381
	6375:	Unidentified	—
	6634	Unidentified	—
	6809	H 6563	+0.0375
	6959:	He I 6678?	+0.0420:
28 February 1979	4515:	H 4340	+0.0403:
2.3-m	5052	H 4861	+0.0392
	5419:	He II 5411 rest?	—
	5814:	C IV rest?	—
	6109	He I 5876	+0.0396
	6386:	Unidentified	—
	6628	Unidentified	—
	6812	H 6563	+0.0379
	6955	He I 6678?	+0.0415:

Colons or double colons after an entry indicate values that are uncertain or very uncertain.

These observations of SS433 were obtained on 2 and 3 December 1978 UT using the Steward 2.3-m reflector, Cassegrain spectrograph and intensified Reticon detector system in conjunction with circular polarisation analysers. The analysers consisted of quarter wave plates constructed from multiple layer interference filters followed by sheet polaroid orientated to transmit opposite senses of circular polarisation over the relevant wavelengths. The analysers were placed ahead of the 5 arc s entrance aperture. The object was observed alternately through the first aperture, then the second, in the manner of a single channel polarimeter. Differing wavelength transmission properties of the polaroids were removed by observation of a continuum lamp.

The scans were obtained with the object about three hours west of meridian for 40 and 20 min total integration times, respectively, on the two evenings. Figure 1 shows in *a* and *b*, the total intensity spectra for each night; in *c*, a division of the two total intensity spectra; and in *d* a division of the spectra for 2 December having opposite circular polarisations. Some variable emission features similar to those previously discussed[5] are marked in the 2–3 December spectra (*a*, *b*). However, we find no evidence for these or any other features in the circular polarisation spectrum. Preliminary broad-band circular polarisation measurements (on 27 November 1978) suggested that the overall optical polarisation did not exceed 0.1%. The lines and continuum could conceivably be depolarised by a mechanism such as electron scattering or propagation through a strongly magnetised plasma. However, as Fabian and Rees[6] have pointed out, there is also a severe size/brightness temperature constraint for the required emission luminosity.

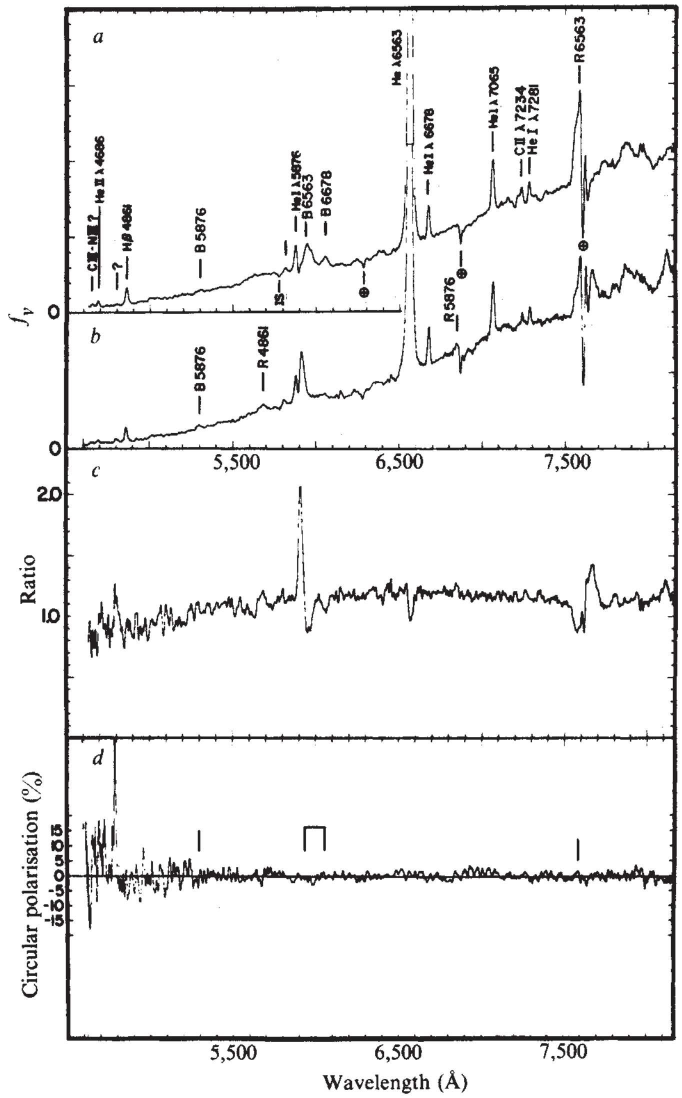

Fig. 1 Steward intensified Reticon spectrophotometry of SS433 on 2 and 3 December 1978. *a*, *b*, Total intensity spectra for each night. The rest system emission lines are identified as are emission features identified with either the redshift (R) or blueshift (B) systems; the labels correspond to the rest system wavelengths. Strong terrestrial and interstellar absorption is indicated. Thus R6563 is identified with the Margon *et al.*[5] "infrared", and B6563 is their "red" feature (see Table 1). *a*, 2 December; *b*, 3 December. *c*, Wavelength changes in the moving features between the two nights are shown by dividing the 3 December Steward scan by the 2 December scan. *d*, Circular spectropolarimetry for 2 December, as described in the text. Positions of the principal moving features are indicated.

This constraint rules out the magnetospheres of degenerate stars observed to have high fields. A massive main sequence star magnetised to the limit in which the magnetic energy approaches the gravitational energy would be needed. In any case, the following results show that the moving emission features are not Zeeman components.

Velocity fits to the moving features

In addition to the Steward spectra of 2 and 3 December, spectrophotometric evidence was obtained using the McGraw-Hill Observatory 1.3-m and 2,000-channel intensified Reticon spectrometer on 27 November and 3 December. Further Steward spectrophotometric evidence was obtained on 27 and 28 February 1979. All but the 27 November scan show strong features similar to those described by Margon *et al.* Again the features seem to vary greatly in position and profile.

Since Hα is expected to be the strongest line emitted by a normal composition gas over a wide range of excitations—and is very strong in the SS433 'rest' emission line system—we examined the possibility that the strong moving features similar to the 'red' and 'infrared' features of Margon *et al.* were Hα lines from a velocity-shifted gas. The hypothesised velocities are enormous for an object suspected to be within the galaxy: some 5×10^4 km s^{-1} for the redshift and 2.7×10^4 km s^{-1} for the blueshift. Our December spectra covered much of the visible spectrum at good signal-to-noise ratio and showed weaker, variable emission features. If the velocity interpretation were correct, then their positions could be expected to match wavelengths for other lines of H, He I, He II, and so on, in the redshift or blueshift systems hypothesised for Hα. Remarkably, it was possible to account for most of the significant weak features with velocity-shifted lines of Hβ, He I λ5876 and He I λ6678—all strong lines in the rest system. These results are listed in Tables 1 and 2.

Table 2 Mean velocity shifts from SS433 spectrophotometry

Date	Blueshift	Redshift
2 December 1978	-0.0946 ± 0.002	$+0.158$:
3 December 1978	-0.0985 ± 0.001	$+0.1672\pm0.004$
27 February 1979	—	$+0.0383\pm0.0015$
28 February 1979	—	$+0.0394\pm0.0012$

The probability that such a good match could be made by chance is quite low. However, a definitive test of the identifications would be to show that these weaker features move as the Hα components move. Unfortunately, the weakness of the features and the blending with atmospheric bands prevented us from making a conclusive test for the 2–3 December data.

When the object was re-observed on 27 February 1979 (Fig. 2), a very strong infrared feature was found quite close to Hα (~6,800 Å), affording an uncluttered test of our hypothesis of a redshift system. Indeed, strong features with corresponding small velocities appeared redwards of Hβ, He I λ5876 and probably Hγ (Table 2). Moreover, the features have similar, complicated profiles, suggesting extended double peaks with skewed wings to longer wavelengths. This similarity is, of course, expected if they come from the same gas. On 28 February, no statistically significant shifts in these features had occurred. However, their profiles all appeared distinctly sharper; identification of corresponding He I λ6678 and λ7065 lines in these spectra is confused by blending.

Surprisingly, there was little evidence for a well separated blueshift system on 27 and 28 February. There are much weaker, unidentified features present which might be blueshifted Hα; but searches for corresponding Hβ/He I features are frustrated by their weakness. Extended wings and structure on the short-wavelength sides of the rest Hα, and Hβ suggest that a strong blue system might just be emerging near zero velocity. It is of interest to compare these scans with that published by Clark and Murdin[1]; the latter showed an unidentified feature at λ6490 which may be blueshifted Hα but no evidence for a redshift system, at least out to λ6800 where the scan ends.

Implications

We have shown that the features in our data are due to hydrogen and neutral helium lines undergoing very large velocity (and perhaps gravitational) shifts. Margon, Ford and Katz (unpublished) have independently reached a similar conclusion concerning their spectrophotometry. A detailed discussion of alternative models[6–9] should be deferred until a comprehensive set of observations is available. However, the following remarks should be relevant.

(1) The velocity-shifted gas clearly is not very hot: it is near the ionisation temperature of He I and H, but not He II. Apart from the lack of He II λ4686 in the moving system, there is no evidence for forbidden lines such as [O I] λ6300, [O III] λ5007, and [O II] λ7319, 7330.

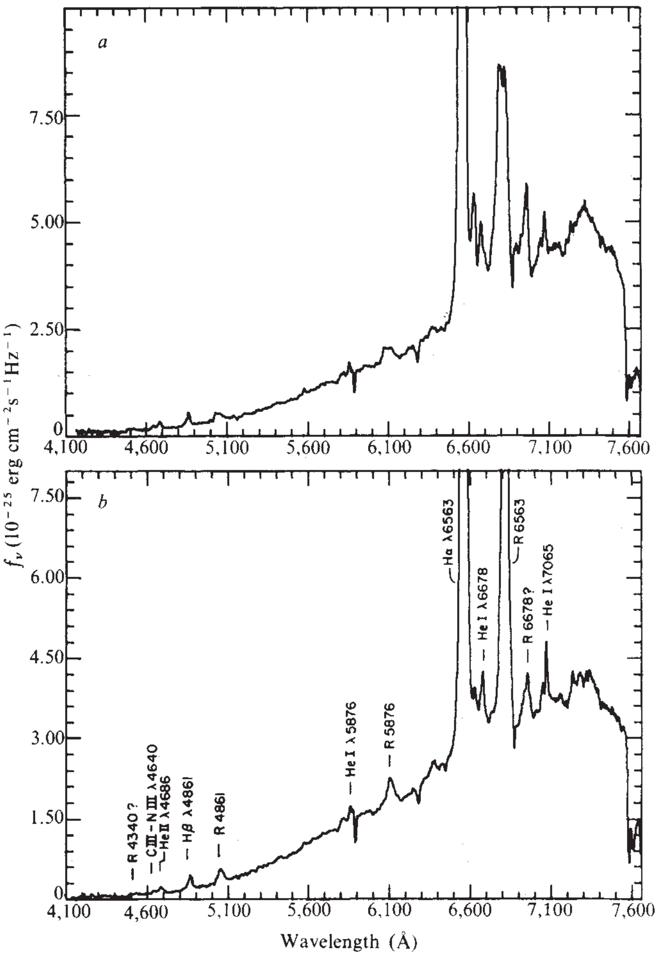

Fig. 2 Steward spectrophotometry for 27 February (*a*) and 28 February (*b*). The peak of the λ6812 redshifted Hα feature for 28 February does not appear on the truncated plot but lies at ~3.8 times the nearby continuum intensity and at ~0.37 of the Hα rest line peak. Labels on the 28 February plot follow the Fig. 1 format.

(2) While the moving features may sometimes appear quite narrow (for example the blueshifted Hα line on 3 December is 50 Å FWHM), they may also appear with complicated profiles. Note that the redshifted features on 27 February have sharp violet edges but are skewed to longer wavelengths away from the rest wavelengths; quite the opposite would normally be expected for a very thin, limb-brightened disk[7].

(3) If the blueshift system is assumed to be absent or near zero velocity on 27–28 February, while a strong redshift system is present at $z\sim0.04$, several implications are evident: a very small inclination angle would be required for a black hole

accretion disk model if the gravitational redshift term is to equal the velocity blueshift for gas at only a few Schwarzschild radii. Previously, Terlevich and Pringle[7] fitted a moderate inclination angle (45°) to the Margon *et al.* features for 23–26 October 1978. For a double ejection model, there is a different inference: since the Margon *et al.*[5] paper and our earlier data suggest that the high velocity gas is generally seen to accelerate, the positive-velocity gas on 27–28 February would apparently have been ejected somewhat earlier than the negative-velocity gas (regardless of the light travel times between ejected systems). Alternatively, the transverse Doppler shift could produce a displacement to longer wavelengths for both velocity-shifted components if the total velocities were ~0.2–0.3 *c*. Finally, we discount the possibility that the unidentified emission line at ~λ6630 is the blueshifted Hα component at a position longwards of rest Hα because it is much weaker and narrower than the λ6810 redshifted component.

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Note added 26 April 1979: Two important new developments from optical spectrophotometry have occurred since this paper was first submitted.

(1) Margon *et al.*[10] have reported that the line positions for both the blueshifted and redshifted systems recur with period 160 ± 3 d, or an integer multiple thereof. The two systems seem to reach maximum positive and negative velocities of +50,000 and −30,000 km s^{-1}; the minimum velocities have not been determined. These conclusions are consistent with recently obtained Steward velocity points (which were included in the UCLA data base).

(2) High resolution (~2.5–5 Å) scans obtained on 4, 5 and 6 April 1979 and similar data obtained on scattered nights during March confirm that strong blueshifted absorption lines often occur near the Hβ, Hγ and He I λ4471 emission lines of the 'rest wavelength' system; the scans show that the absorption lines are highly variable in strength from night to night. He II λ4686 absorption is not seen. These sporadic 'P Cygni' profiles suggest the ejection of cool gas with ≤1,000 km s^{-1} velocity widths from the region producing the rest emission lines. The rapid variability indicates that this region has a size of the order of one light day. Such a scale is not readily compatible with a massive black hole model for the system.

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Biologically active phorbol esters specifically alter affinity of epidermal growth factor membrane receptors

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TPA (12-O-tetradecanoyl-phorbol-13-acetate) reversibly inhibits the binding of ^{125}*I-labelled epidermal growth factor (EGF) to treated mouse and human cells, but does not affect the binding of various other ligands to their membrane receptors. It alters the affinity of the receptors for EGF without changing the total number of available receptors per cell. Those phorbol esters which stimulate cell growth in culture and have tumour-promoting activity* in vivo *alter the EGF-receptor affinity, while the biologically inactive derivatives fail to change the affinity of EGF for its receptors.*

TUMOUR PROMOTERS are compounds which are not themselves carcinogenic but which can induce tumours in mice previously treated with a suboptimal dose of certain chemical carcinogens[1–4]. One of the most potent tumour promoting agents is TPA (12-*O*-tetradecanoyl-phorbol-13-acetate), initially isolated from croton oil[5]. Tumour promoters modulate an array of biochemical functions in mouse skin, including the stimulation of DNA, RNA and protein synthesis[4]. TPA also evokes various biological and biochemical changes when added to cultured cells, including the stimulation of DNA synthesis[4,6,7] and cell proliferation[4,6–8], induction of plasminogen activator[9] and ornithine decarboxylase[10], loss of surface-associated fibronectin[11], either inhibition or stimulation of differentiation[1–4], and alteration in cell permeability[12].

The amphiphatic nature of the TPA molecule, and several other lines of evidence, suggest that the initial site of action of TPA and other related promoting agents is the membrane of the target cell[2,3,12–15]. The nature of the biological and biochemical responses initiated by TPA *in vivo* as well as *in vitro*, has many similarities with those of growth stimulating polypeptide hormones such as epidermal growth factor (EGF)[16] and sarcoma growth factor (SGF)[17].

The above considerations led to the investigation of the effects of TPA and related tumour promoters on the interactions between EGF and its membrane receptors. A recent report by Lee and Weinstein describes the effect of TPA on epidermal growth factor binding to HeLa cells[18]. Their data indicate that TPA reduces the number of EGF receptors available for binding the ligand[18], whereas the studies described here suggest that TPA reduces the binding of EGF to its receptors by reducing the affinity of the EGF receptor–ligand interaction, while not affecting the total number of available EGF receptors. There is also a good correlation between the degree of modulation of the EGF–receptor interactions by the various derivatives of phorbol and their ability to act as promoters of carcinogenesis both in cell culture and in mouse skin.

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