Memorandum from the Royal Astronomical Society

Astronomers have been very concerned about the impact of increasing light pollution on the study of astronomy, the observation of astronomical phenomena by professional scientists and amateurs, and the loss of the night sky as a matter of general scientific interest. There is considerable evidence that many young people are attracted to science through an interest in astronomy, not least because they have experienced the scientific universe personally. As the brightness of the stars fades under the progressive glare of light pollution, this personal experience of astronomy becomes weaker. There is a real danger that this stimulus to scientific interest will be lost to our future generations.

The RAS formally protested to the Director General Space Regatta Consortium about the Znamya-2.5 space mirror experiment in 1998. The International Astronomical Union has passed resolutions at eight general assemblies on the issue of light pollution and related matters (see section S5), and in 1999 the International Astronomical Union and the United Nations Special Environment Symposium "Preserving the Astronomical Sky" made several recommendations to Member States.

There have been several conferences where the issue of light pollution and astronomy has been discussed and good practice shared. This submission draws heavily on these conferences, in particular the UNESCO conference in 1992, "The Vanishing Universe" (edited by Derek McNally). In addition to the formal responses to the five questions, several sections of supplementary information (S1 to S5) are presented, and the Committee is invited to consider three additional related matters:

A1. The UK role in the international control of light pollution.
A2. The adverse impact of other pollution, in particular radio frequency interference, on UK facilities.
A3. Space-based light pollution and space art.

Supplementary information:

S1. Definition of ALCORs (Astronomical Lighting Control Regions for Optical Observatories).
S2. Definition of forms of light pollution.
S3. Lighting options available.
S4. Guidelines for lighting to avoid light pollution.
S5. Summary of relevant IAU General Assembly and IAU/UN Symposium recommendations.

Question 1. What has been the impact of light pollution on UK astronomy?

The impact of light pollution on UK astronomy has been major.

Post-war, in the 1950s, the Royal Greenwich Observatory had to leave London because of light and smoke pollution, and moved to the site in Sussex, only to move again within 30 years because of light pollution, out of the UK. Post-war, several universities in the UK had teaching and research programmes to train astronomers in observational astronomy during their educational career (including London, Cambridge, Durham, Hatfield, Edinburgh, St Andrews, Armagh). All these universities have found it increasingly difficult (or even impossible) to continue with active programmes of astronomical observations from the UK, now that light pollution has reached the stage at which only the brighter objects can be viewed from typical university locations. Yet, paradoxically, as it becomes more difficult to carry out astronomical observations in practice, there is an increasing interest in astronomy in universities. About 50 universities, ie about half the universities in the UK, offer undergraduate courses to a significant extent and about a quarter offer PhD training, which attracts considerable funding and overseas students. Training is carried out either on easily observed astronomical objects, theoretically, or by use of sites overseas for observing. Liverpool John Moores University is one university, which mounts a formal overseas expedition for direct astronomical observation (to Tenerife for two weeks). The undergraduate students, for practical reasons few in number, who have this experience return to the UK visibly fired up with enthusiasm for science.

Possibly the best situated observatory in the UK is now St Andrews, due to the care of their local Town Council in enforcing lighting regulations (drawn up in consultation with the University Astronomy Department). An active but

reducing observational astronomy research programme continues at Cambridge University, but with repeated battles on light pollution issues each time new developments (eg large building complexes, sports fields) are at the planning stage. (See section A1 for comments on the international issues.)

In the UK the problem is exacerbated by the multiple agencies responsible for lighting. Consequently, astronomers favour national controls and have considered how a national scheme could be implemented. One proposal is to identify "sites" in the UK where astronomical observing takes place, classify them under a scheme called ALCORs (Astronomical Lighting Control Regions) and define national standards accordingly. (See Supplementary Information section S1). The ALCOR scheme was drawn up to be compatible with a similar scheme proposed for control of light pollution effects on natural areas such as wildlife habitats. Once an observatory, or even a dark location which amateur astronomers regularly use, has been registered in one of the categories, then local and highway authorities would be aware (in a formal sense) of their responsibilities. This scheme could include the many important observatories, where the general public can go and which often play an important teaching role (for example, the Royal Observatory Greenwich, the Herstmonceux Science Centre, Sidmouth, Dundee), giving them the opportunity to continue their work.

Many scientists were drawn to their careers by the excitement of observing the night sky, either the wonder of the thousands of faint stars in the Milky Way, the galaxies and nebulae, or phenomena such as comets, meteors and aurorae—and these are lost to the young due to light pollution. It should be a cause for grave concern that education in science suffers from the lack of opportunity to see such things.

Recommendation: The RAS recommends that a list of places to be protected by appropriate ALCOR status be established and distributed to local authorities (and other planning bodies) for them to include in their planning activities.

Question 2. Are current planning guidelines strong enough to protect against light pollution?

No, planning guidelines are drawn up locally to address local concerns, and these are not adequate for astronomy. Local authorities with control of planning issues are quite small whereas the range of light pollution may be large, so astronomical facilities in one authority may be affected by lighting decisions in another. Road lighting is controlled by other agencies, literally cutting across areas.

There are several types of light pollution (see Supplementary Information, section S2), professional astronomers are most concerned with Urban Sky Glow. This type of light pollution appears to be rarely addressed in planning applications, unless there are established concerns from a particular observatory in the area. Plans will show an illuminated car park—the plans should as a matter of routine indicate where the light from the lighting fixtures will shine, and how much will be wasted by shining upwards (causing sky glow), or outside the car park area (causing light trespass and glare).

Often the work of a concerned local Council can be adversely affected by neighbouring Councils, for example the work of St Andrews Town Council is weakened by the Urban Sky Glow from Dundee to the north. Many sources of light pollution are "out of town", having bright security lighting due to their remoter location, regardless of professional and amateur astronomers needs. There appears to be a lack of appreciation that overbright security lighting creates "glare" (see S2), which makes it more difficult to see intruders, than lights without glare which illuminate the secured zone so that it can be easily examined from outside.

London, as seen from the air or from space illustrates many of the problems. Light that shines on the ground (eg from a road or car park surface) will inevitably reflect upwards but there is no need for astronauts in the International Space Station or pilots of aircraft to be able to see the lights themselves (except any needed for navigation purposes—see S2 for

confusion). A light that is directly visible from the passenger window of an aircraft represents wasted energy. The UK contrasts badly with examples of better practice, for example Arizona, where there are many observatories of international standard. Cities such as Phoenix, Tuscon and Flagstaff require full cut-off lighting for roads and for security purposes, and are examples of what the UK could achieve.

Recommendation: The RAS recommends that planning regulations include limits on sky glow (also light trespass and glare).

Question 3. Are planning guidelines being applied and enforced effectively?

Anecdotally, this seems unlikely. Planners are often sympathetic once a problem is pointed out to them, but persuading the offender to change existing lighting, adding expense, can be difficult.

Out of town complexes and industrial estates often have intense security lighting, which appears to work on the "more is better" principle, rather than by considering their actual needs. Sports facilities do not need to be floodlit all night, nor lit so that the illuminated area is outside the field of play. In the best practice, a sports field will use lighting that shines on the field of play when it is use.

Question 4. Is light measurable in such a way as to make legally enforceable regulatory controls feasible?

Lighting is measured in lumens, and devices exist. The RAS assumes other organisations such as the Institution of Lighting Engineers have guidelines available (for example the ILE has guidelines on design—see Supplementary Information section S3). The shape and positioning of lighting fixtures can be modelled. There are practical limitations in what can be achieved, for example, in the size of the light emitting device within its reflecting housing, but good designs exist and their use and implementation is a matter of common sense rather than sophisticated analysis.

Question 5. Are further controls on design of lighting necessary?

Conferences have shown that lighting engineers, householders worried about intruders, and the public at large share many of the same concerns as astronomers, and fortunately this is an area where everybody can win, if best practice is followed.

Because the problem is long range and cuts across administrative boundaries, a national strategy is needed, to draw up and enforce regulations uniformly, and to support lighting engineers in making the appropriate decisions, based both on local facts and information, and an awareness of likely implications to facilities further away.

Poor lighting gives rise to light pollution. It also wastes energy (and therefore money). The Kyoto protocol should influence the UK to try and improve lighting quality and cut energy costs. Europe sends around a 1,000 million pounds sterling into the sky as light pollution. Just as effective insulation is a strategy to reduce domestic heating bills, control of light pollution by effective design and implementation are strategies to reduce light costs.

Astronomers find that Low Pressure Sodium (LPS) lighting has least impact on professional work since it is monochromatic (and can be appropriately filtered away), and would urge that this be the standard, requiring a substantial case for any other sort of lighting. It is often pointed out that LPS has low colour discrimination, but this is usually offset by the ambient light from other sources (car headlights, nearby store lighting, etc). Purely on a comparison of lumens produced compared to energy consumed, LPS is superior to incandescent, mercury, metal-halide, and high-pressure sodium lighting, although the other cost factors such as electrical control gear etc offset the power reduction for LPS.

Recommendation: The RAS recommends national guidelines for avoiding light pollution, such as those given in section S4, are implemented.

ADDITIONAL ISSUES FOR CONSIDERATION

A1. The UK role in the international control of light pollution

The UK should be vigilant about the international sites in which it has invested (Australia, La Palma, Hawaii, Chile), and monitor the agreements. The agreements often have severe restrictions placed on these excellent sites. Two examples are the agreement for the Anglo-Australian Observatory, which defines a zone within 18 kilometres of the Observatory in which special restrictions apply (the agreement includes a table of permitted emission rates (in lumens) at specified distances from the Observatory), and the Canary Islands Sky Law (Royal Decree 243/1992), which protects the astronomical qualities of the observatories on Tenerife and La Palma, and places restrictions on outdoor lighting, radio transmitters and industries or other activities which could create pollutants. The regulations are typically monitored by the host organisations and enforced by law at a high level. For example, in the Canary Islands, the Instituto de Astrofisica de Canarias has a permanent light pollution office to make measurements and identify causes for concern (whether large scale lighting projects or individual lighting schemes). The Chilean agreements are monitored largely by the Office for the Protection of the Skies of Northern Chile (funded by the Chilean Government's Environment Commission—CONAMA), and enforced by the National Superintendent of Electricity and Fuels.

A2. The adverse impact of other pollution, in particular radio frequency interference, on UK facilities

The UK should be vigilant about the associated issues of radio frequency interference and pollution which could curtail the work of the Lovell telescope at Jodrell Bank, the MERLIN radio telescope network in the UK, and the UK radio telescopes' work internationally (for example, as part of the Very Long Baseline Interferometer network). The UK is part of the international group building the Atacama Large Millimetre Array (ALMA) in northern Chile, and so should monitor the radio frequency interference protection there.

The UN Member States (nationally, internationally and with industry) should cooperate to implement suitable regulations to preserve quiet frequency bands for radio astronomy and remote sensing from space, and to develop and implement, as a matter of urgency, practical technical solutions to reduce unwanted radio emissions and other undesirable side-effects from telecommunications satellites. UN Member States should cooperate to explore new mechanisms to protect selected regions of Earth and space from radio emissions (radio quiet zones) and to develop innovative techniques that will optimise the conditions for scientific and space activities to share the radio spectrum and coexist in space. (From "Preserving the Astronomical Sky" recommendations)

A3. Space-based light pollution and space art

Optical astronomy has already suffered from space-based pollution, caused by the Iridium satellites and by space debris, just as radio astronomy has been inhibited by the Russian GLONASS satellites, which transmit sideband interference. Experiments continue to be proposed which would place strongly luminous objects in space, whether for technology assessment (generation and transmission of illumination or power), or for artistic or commercial purposes (space art or space advertising). Although space agencies are sympathetic to scientific needs in general, currently, no international regulations exist to prevent uncontrolled private and other enterprises from launching objects into space that would ruin the night sky for people of all nations potentially for many generations. The recent reduction in the space market after the downturn in the technology industrial sector makes it more likely that space launcher companies will seek new markets such as advertising. Unlike ground-based art or advertising, space displays respect no national boundaries or environmental regulations. An international treaty is needed to prevent unbridled proliferation of such displays to the irreparable detriment of scientific progress. (From "Preserving the Astronomical Sky" recommendations)

UK University Observatories Actively Used (or Available) for Teaching

1. Armagh Observatory (accessible to University)
2. Queen's University Belfast
3. University of Birmingham
4. University of Bristol
5. Cambridge University
6. Cardiff University
7. University of Dundee
8. University of Durham
9. Royal Observatory Edinburgh (accessible to University)
10. University of Exeter
11. University of Glamorgan
12. University of Glasgow
13. University of Hertfordshire
14. Keele University
15. University of Kent
16. University of Central Lancashire
17. Lancaster University
18. University of Leicester
19. University of Liverpool
20. Liverpool John Moores University
21. University College London
22. Queen Mary University of London (infrared)
23. University of Manchester
24. University of Newcastle on Tyne
25. University of Nottingham
26. Open University
27. University of Oxford
28. University of Plymouth
29. University of St Andrews
30. University of Sheffield

31. University of Southampton
32. University of Sussex
33. University of Wales, Aberystwyth

(Taken from Astronomy Now Education Supplement, October 2001, by John Murrell and supplemented by Dr Helen Walker from personal knowledge.)

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