A Simple and Inexpensive Spectrometer Wavelength Calibrator

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Introduction

After building a medium resolution spectrometer (R=3000, described on my web site above), I needed wavelength calibration source. After gaining experience with a neon bulb and various fluorescent lamps, I realized that I needed a better choice of lines from a source that could be easily remote controlled and that would match the selected wavelength range being measured by the spectrometer.

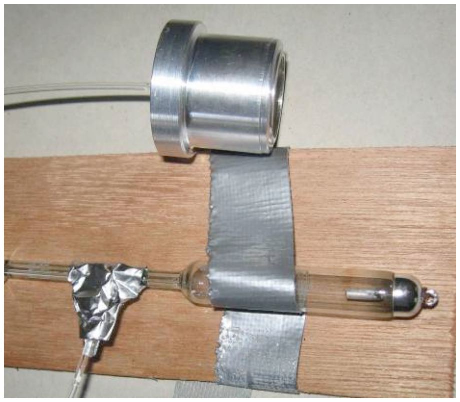
The final solution uses small ampoules of gas excited externally from a 12V:2KV power supply in a 1 1/4 in dia package that fits into standard telescope fittings, all at a cost of about $100.

Discussion

My application is on a home built R=3000 spectrometer fitted to an 18in. f3.5 Newtonian telescope (all described on our web site). Although the resolution of the spectrometer is of order 2A, its stability is such that line shifts of 0.1-0.2A can be detected; however, precision wavelength calibration is required both for absolute wavelength measurement and to assure that the calibration does not change day to day. The spectrometer has a fitting that accepts the wavelength calibrator in a standard 1 1/4in. dia telescope eyepiece fitting. The light path into the spectrometer includes a pellicle (8% reflecting mirror) that reflects some of the light into the spectrometer slit. It is also desired that the lamp can be switched remotely (and ultimately under automated control), so the power source must be 12v and the lamp must start quickly and reliably. The design should allow different gasses to be used to match the wavelength scale (eg., Neon is fine at red or 6000-7000A but had little green or blue emission).

Event the initial Neon calibrator was not easy to operate properly. I did not want to run 120v on the telescope, and simple converters (as found on Google) from 12vDC tend to be very poor quality AC, such that the bulb blackens quickly. In addition, the bulb (in the dark) often would resist starting. The best driver was an inexpensive ($5), small, cold cathode fluorescent driver (see references). Small bulbs similar to the NE2 neon bulb that contain other gases are either extremely expensive or simply not available.

Although gas discharge tubes for use as spectrum sources are reasonably available, most are quite expensive ($200 and up) and require awkward high voltage sources. The standard shape is a tube about 0.5dia by about 8in. long, with a long narrow neck in the middle third to concentrate the light intensity. The tubes are normally driven by 2-5KV applied to electrodes on the ends.



The picture shows a standard tube which I fitted with a single optical fibre to carry some of the light through an 1 1/4in. fitting into the spectrometer. The fibre was epoxied to the narrow neck of the discharge tube, and reinforced with aluminum foil. This worked fairly well, as driven by the 12V:2KVAC power supply (discussed below). However, the physical arrangement of the tube and wiring was very awkward, and of course, very prone to breakage. Also, the ability to change to a different discharge tube would require a complete optical fibre setup. Finally, the exposed tube and wiring produced local rf interference, leading to the possibility of affecting other observatory equipment.

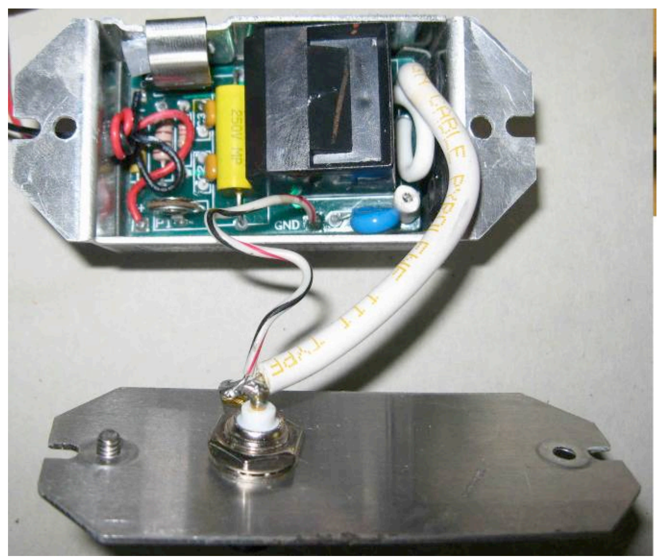
An alternative to the standard discharge tube was to use a small (0.5in x2in long) ampoule containing the gas of interest (these are apparently sold mostly to people who wish to collect samples of the elements). These can be obtained at low cost (approx. $25 each). They have no electrodes; however, external wires or contacts close to the ends of the ampoule, energized by 2-5KVAC, will excite the tube to glow. The challenge is then the physical and electrical design.

Power Supply and Ampoule Holder

The power used for most of these experiments is an inexpensive (($38) 12VDC @1A converter to 2KVAC, frequency about 25KHz as shown in the picture. Experiments showed that this supply would drive either type of tube, either via electrodes or externally. The power supply has two 18inch HV leads, each with an alligator clip.

To enclose the ampoule in a convenient, shielded holder, I built the simple device shown in the picture. There is a 1 1/4in OD tube, internally threaded. Into one end is screwed a simple plate with a 7/16in hole. The rounded end of the ampoule centers itself in this hole, and this is the place of light emission from the ampoule. The left end of the 1 1/4 tube is capped by a plate containing a BNC connector for the HV connections (center and ground). A simple spring made of .024 stainless steel wire supports the pointed end of the ampoule. This spring centers the ampoule, and provides a gentle force holding the ampoule against the 7/16in. opening in the opposite end and allows for differing length ampoules. The spring at one end with its high voltage and the edge of the hole at the other end (at ground), provide the two "external electrodes" to excite the tube. Finally, there is an optional plastic cylinder to help center and hold the ampoule. Note that BNC connectors are not rated for this high a voltage; however, experience shows that for this kind of service, they perform quite well.

Initial tests were frustrating. I had connected the two HV wires to a second BNC connector, then used a double male to connect the HV to the ampoule. While operation was fine on the bench, it would not operate on the telescope. Investigation showed that one of the HV leads was "hot" and one was at AC ground, but I had unknowingly connected the hot to the system ground, thus shorting the HV when connected to the grounded spectrometer. In addition, there was obvious rf interference.

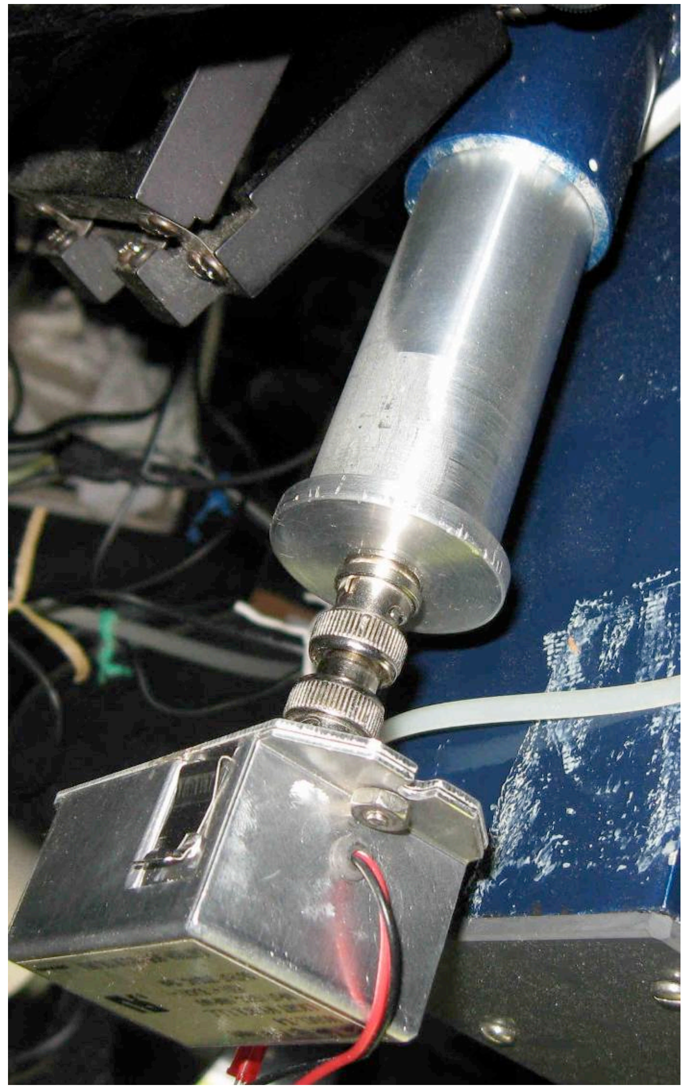


To allow fully enclosed (shielded) operation, I modified the power supply as follows. Open the power supply by drilling out the rivets holding the base. Install a BNC with ground lug in the base. Obviously, make sure the BNC connector has good clearance from other components inside the box. Remove the heat sink clip (top left of box) and insulating tape with white heat sink compound, unsnake the wires, and pull the small circuit board out of the box. Cut off the AC Ground HV lead (lower right corner inside box). Install a small wire from the pad marked "GND" to the BNC ground lug. Cut the second HV wire off at about 3 in., and solder to the BNC center pin. Wrap 4-6 layers of electrical tape (not shown) around the center BNC contact. Using 6-32 screws in place of the rivets, reassemble the unit (replacing the heat sink clip and tape as they were).

A simple double male BNC will connect the power supply to the ampoule holder in a very compact, light weight package (see picture). 12V for the power supply comes from your system of choice (in my case, from a remote operated switch system).

Addendum. After some use, the high voltage began to burn through the fish paper insulator beneath the HV lead pc board solder connection. I suggest removing all sharp edges on the underside of the HV connection, plus adding a half dozen layers of insulating tape. Also, cut electrical tape into 1/4 inch strips, remove sharp points, and insulate the BNC solder joint.

Results



The system works well--reliable operation, no rf noise, etc. The light intensity is not high; however, in spite of the distance the light must travel, and the poor reflection of the pellicle, and the fairly high spectrometer resolution, an exposure of about 4 sec gives perfectly useful spectra for calibration purposes (Xenon at Ha wavelengths). The remote operation means that I can run a calibration automatically every half hour during long spectroscopic sequences (I use a simple scripting operation within MaximDL or other programs). Changing to a different ampoule takes only a few minutes, and involves no special tools or calibrations.

References

Source for standard discharge tubes and for HV power supply:
http://www.socalnevadausa.com/servlet/the-Neon-%26-Related-HV-Apparatus/Categories or via Ebay

Source for Ampoules in Austria (they also sell the above HV supply):
www.smart-elements.com or via Ebay

Cold Fluorescent Driver (used for neon bulb):
All Electronics http://www.allelectronics.com/make-a-store/item/INV-1125/CCFL-INVERTER/1.html

Site for identifying wavelengths of gas discharges:
http://astro.u-strasbg.fr/~koppen/discharge/index.html