

CHEAP AND STURDY STUDENT TELESCOPES MADE WITH PLUMBING PARTS . J. P. Edmonds and G. F. Brandenburg, Carnegie Academy for Science Education, Carnegie Institution of Washington, 1530 P St. NW Washington DC 20005, jedmonds@ciw

What better way to honor the 400th anniversary of the invention of the astronomical telescope than to have students make and use their very own telescopes? Recently, the 20 middle school students in Carnegie's First Light Saturday Science School did just that.

These students had previously constructed 4 and 6-inch Dsonian reflectors but we found these unwieldy for casual observations due to their size and the need for adult supervision. Rather than use one of the several commercially available kits (that are in limited supply this year), we came up with our own design that may easily reproduced at a very low cost using readily available materials.

The plan was to use standard PVC plumbing pipe to house the optics. We reasoned that we would need objectives and eyepieces to fit into 2-inch and 1-inch pipe respectively. At a nearby surplus warehouse, we purchased cemented doublet lenses with a diameter of 52 millimeters and a focal length of 220 mm, which is quite 'fast' for achromats. To go with the objective lenses, we also purchased 20-mm and 12-mm 0.965" eyepieces so that each student would get one of each. The total price of the optics, for each scope, was \$13.50.

With the guidance of veteran staff at a local hardware store, we devised a way to connect a nominal 2-inch inner diameter PVC tube, which would hold the objective lens securely, to a 1-inch inner diameter PVC tube, in such a way that the components would be held steady, but students could slide something in and out to focus on near or distant objects. We used a PVC 2-inch to one-and-a-half inch reducer, followed by a PVC one-and-a-half inch to one-and-a-quarter inch junction, followed by a piece of 1¼ PVC pipe. Inside that, we could slide a piece of one-inch PVC pipe which had an *outside* diameter that was almost, but not quite, 1.25 inches. A few layers of masking tape would build up the outer diameter of the last one-inch PVC pipe so that it would fit snugly inside the 1¼ inch pipe and allow the student to slide it back and forth for the purpose of focusing. The 0.965-inch outer diameter eyepieces would also need a few layers of masking tape so that they would fit into the one-inch tubing. Finally, to protect and shade the achromatic objective, a two-inch to two-inch PVC junction collar would be put on the front of the telescope. The total cost of the PVC pipe and junctions was approximately \$5 per scope.

The students had a great time putting the telescopes together. Following directions, and under adult super-

vision, they measured and sawed appropriate lengths of 1½" and 1" PVC tubing, wrapped masking tape around the latter, fitted all of the parts together, and then used PVC pipe cement to glue the appropriate parts together. They used fast-drying plastic spray paint, indelible markers, and colored tape to make them beautiful. They also painted the inside of the tube black to reduce internal reflections.

The entire telescope, including eyepieces and sunshield, is about 12 inches (30 cm) long. These telescopes have relatively short focal ratios (about f/4.2) and relatively wide fields of view. With the 12-mm eyepieces, they magnify by about 18 times, and with the 20-mm eyepieces, about 11x. They are rugged for field use, easily carried and cheap enough (less than \$20 each) so that each student can make and keep their own.

Detailed drawings and instructions will be distributed at this hands-on session.