Introduction to Dark Matter Search

The dark matter problem is fundamental in nature and elusive in particle physics. A survey of the total mass of the universe indicates that only 5% of all matter in the observable universe is baryonic or conventional matter.

- The majority of the matter in the universe, which would account for the observed gravitational interactions, remains unidentified.
- This unidentified matter is difficult to observe because it does not interact with the electromagnetic or strong nuclear forces.
- The observations of galactic rotation and mass distribution in the universe strongly indicates the presence of dark matter.
- PNNL’s bubble chamber prototype will be used to design experiments to detect non-baryonic, Weakly Interacting Massive Particles (WIMPs).
- The detection of non-baryonic matter would help to explain the nature of the universe and why matter and galaxies are able to form in the way they do.

Bubble Nucleation in the Chamber

- The target fluid is held at a temperature greater than the boiling point for that liquid.
- The phase diagram to the right (top) shows the transition of a fluid from a liquid (blue) to a superheated state (red).
- In a metastable state, if sufficient energy is added to the system the superheated fluid becomes vapor.
- The energy provided by a WIMP, alpha, or neutron particle can be sufficient to overcome the energy threshold required to cause a phase change from $\mu_i \rightarrow \mu_v$.

PNNL Bubble Chamber Construction

- Gasket material and $C_4F_{10}$ compatibility for the chamber was investigated to prevent gasket failure and leakage.
- Buna-N and neoprene rubber was determined to be ideal for the gasket application over PTFE material.

Pressure Testing:
- The hydraulic cart was tested for leaks with pressurized air and water.
- The hydraulic system and cold zone were mounted to a ¼" aluminum plate and bolted to 80/20 aluminum frameworks.
- To prevent leaking at connecting points, pipe sealant and Teflon tape was applied to the threads of the NPT connectors.

Assembly:
- The primary components of the hydraulic cart are connected by means of NPT connections and Swagelok compression fittings.
- Copper piping was bent and connected to Swagelok fittings for additional routing of draining, regulating, and pumping oil.

Acknowledgements

The authors would like to thank the following organizations for their support:
- U.S. Department of Energy, Office of Nuclear Physics
- National Science Foundation
- California State University, San Jose, CA
- Pacific Northwest National Laboratory
- CSU and Battelle

References